AMC

COST ANALYSIS HANDBOOK

JANUARY 1968

Prepared For

ARMY MATERIEL COMMAND

Prepared By

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CONTENTS

LIST OF EXHIBITS

FOREWORD

This Handbook provides general but utilitarian guidance for personnel of the Army Materiel Command whose background and experience in cost analysis and cost estimating are modest. As part of this guidance, a description of the environment and the definitional framework for these activities is included. The environment, procedures, and techniques involved in these activities are provided. Inasmuch as the operational framework of cost analysis and cost estimating are virtually one and the same, the cost estimating framework as presented in this Handbook is applicable to both activities.

The sequence of treatment, therefore, follows logically through the chapters. Thus, it is appropriate that the procedures and techniques be presented after the environmental framework.

Cost analysis, as defined in this Handbook, is the basis upon which cost estimating is performed. The discussion of cost analysis, therefore, precedes cost estimating discussions.

The specific methods of accomplishing the cost estimating, referred to as techniques, are explained first and are then followed by an appropriate explanation of procedures: the series of steps, followed in a regular, definite order, to accomplish an estimate. Subsequently, the application of the cost estimating procedures in an example logically completes the sequence before organizational implications are discussed.

The introductory chapter is designed to provide an overview for top management and a general summation of the entire framework-analysis-estimating sequence. Readers may, after studying Chapter I, refer in detail to those subsequent chapters of specific concern, but it is necessary that persons involved in any single aspect of the sequence must be knowledgeable in the other aspects of the sequence. Hence, it is strongly recommended that users of this Handbook study the contents of all chapters.

Chapter I

INTRODUCTION

I-1 PURPOSE AND SCOPE

The purpose of this handbook is to provide guidance and instruction for AMC cost analysis personnel who have modest experience with the subject of cost analysis and cost estimating and/or who may be unfamiliar with the operations of the Army Materiel Command. To this end, it provides a definitional framework for cost analysis and cost estimating and a description of the organizational framework within which costs are utilized.

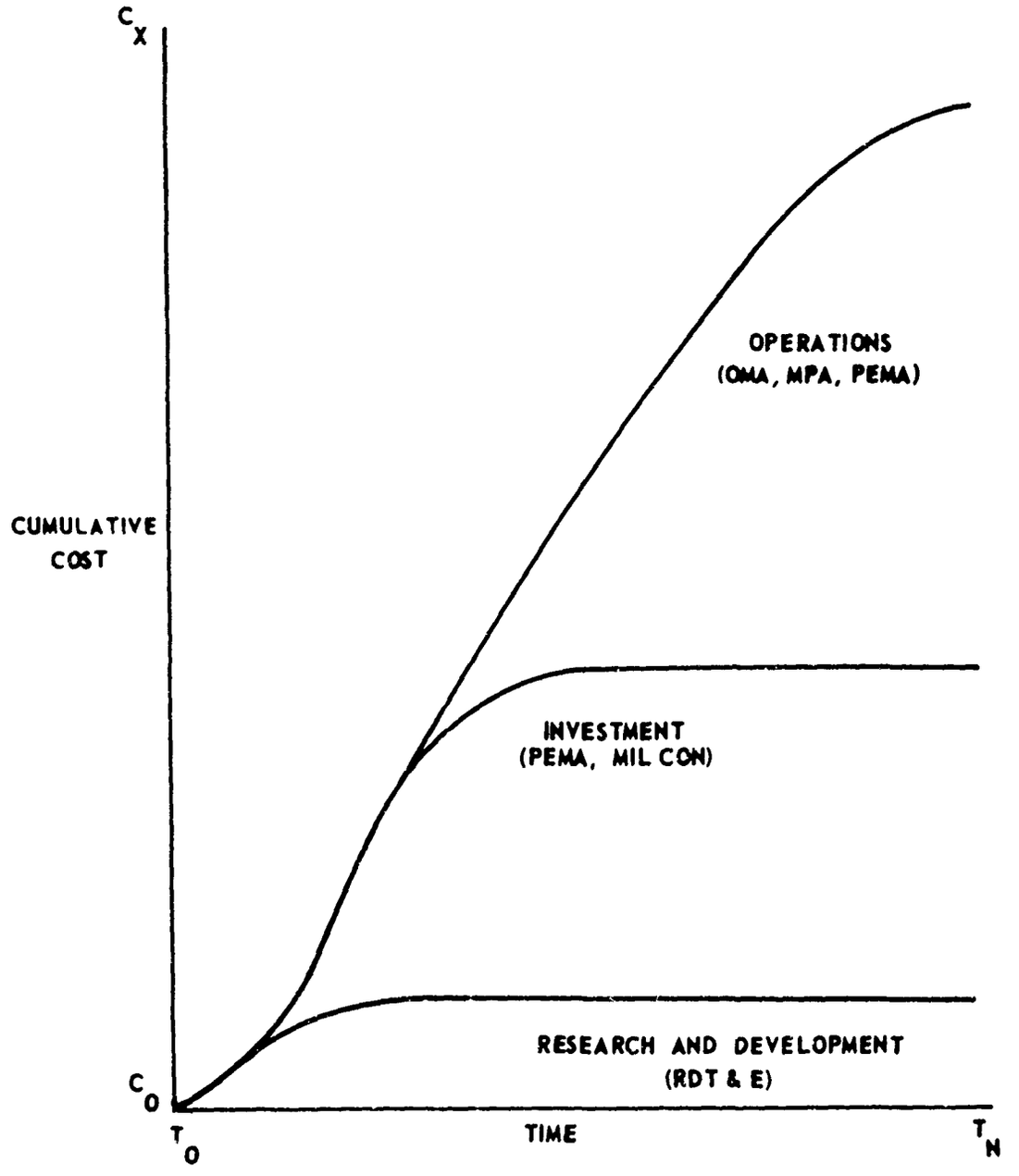
It is expected that the users of this handbook will be primarily involved in the Administrative-Decision Making Function within AMC, supplying cost analyses and cost estimates for decisions related to organization, equipment, maintenance, and deployment of Army forces. In this basic decision making, total costs without reference to such details as time phasing, economic escalation, or minor variations in product characteristics are generally adequate. Once the basic decision is made, however, the cost estimator should be prepared to answer the next question, "How much will this require in Fiscal Year (FY) xx?" and at some subsequent point to compare the estimate with other estimates and actual cost reports.

While the personnel who are expected to utilize this handbook are strongly oriented toward the Administrative-Decision Making Function, some of the terminology associated with the Resource Administration Function is used since these appropriation and contract terms and examples reflect the environments in which background and reference data are found. It is essential that cost analysts and cost estimators, at all levels and in all functional areas, have a working knowledge in appropriations and contracting as a guide to sources of data and to facilitate an understanding of the cost information required and used.

In addition to this, the cost analyst must be aware of the processes for translating ideas (or research) into production programs and operational capability. He must know the life cycle of the hardware (or support system) being costed, the current position of the item in its life cycle, and the role of his cost analysis or cost estimate in the life cycle cost.

The general time phasing of life cycle cost is presented in Exhibit I-1. The three life cycle cost categories have been defined by the Office of the Secretary of Defense (OSD) as:

EXHIBIT I-1
TYPICAL TIME PHASING OF LIFE CYCLE COST



- "Research and Development - Cost primarily associated with development of a new capability to the point where it is ready for introduction into operational use. These costs will include equipment (prototypes, test vehicles, etc.) required in a development program to the extent that such equipment is funded under the RDT&E appropriations. Related Military Construction appropriation costs will also be included. Costs which appear in the Military Personnel, Operation and Maintenance and Procurement appropriations will be excluded from this category.

- Investment - Costs required beyond the development phase to introduce a new capability into operational use. All Military Construction appropriation costs except those associated with development will be included. RDT&E, Military Personnel and Operation and Maintenance appropriation costs will be excluded.

- Operation - Recurring costs required to operate and maintain the capability throughout its projected life in operational use. Military Personnel, Operation and Maintenance and recurring Procurement appropriation costs will be included in this category. RDT&E and Military Construction appropriation costs will be excluded." (Ref. I-1).

n Army appropriation terms these categories are identified as:

- Research and Development
  Research, Development, Test and Evaluation, Army (RDT&E)

- Investment
  Procurement of Equipment and Missiles, Army (PEMA)
  Military Construction, Army (Mil Con)

- Operations
  Procurement of Equipment and Missiles, Army (PEMA)
  Operations and Maintenance, Army (OMA)
  Military Personnel, Army (MPA)

In Exhibit I-1, T_O reflects the point in time when a project or piece of hardware becomes a recognized entity; hence, costs begin to be charged to it. T_N reflects the phase out of the hardware or project item from the inventory. This handbook addresses cost analyses and cost estimates to be performed early in this life cycle at the time when major decisions must be made relative to development of a program. The principal focus is on the procurement (PEMA) implications of specific decisions.

The following section will serve to introduce the reader to the complex subjects of cost analysis and cost estimating and to establish a frame of reference for subsequent chapters.

I-2 COST ANALYSIS AND COST ESTIMATING

The Cost Analysis Activity has been authorized in Program Change Decision A-6-008, subject "Army-Wide Cost Analysis Activity" (Ref. 1-2) with the objectives as quoted below:

> "This PCP* addresses the subject of the current cost analysis capability of the Army and the capability that is required to provide the basis for more effective decision-making. Cost analysis and the information system necessary to support the analysis contribute to many aspects of the decision process. The program described in this PCP describes the analysis required to support estimated costs of development and production of weapon systems, depot maintenance, life cycle costs of weapon systems, cost of training personnel and the cost of operating major force units in the field. In short, this PCP has as its overall objective providing resources to analyze all major costs that are directly related to organizing, equipping, maintaining and deploying Army forces. With respect to the Army-Wide Cost Analysis Program, the overall objective can be divided into several subgoals. The Army must have:
>
> a. A comprehensive system for acquiring, storing, and validating historical cost and economic data to form the basis for cost analysis. This system must not be limited to current and future data from contractors but must also include data from internal historical records.

* Program Change Proposal, currently Program Change Request (PCR)

b. Cost analysis definitions, procedures and methodology that provide one of the bases for quality cost estimates. Also required is a feed-back system that provides a means of constantly improving the cost analysis techniques.

c. A staff of competent full-time professional cost analysts to estimate the costs of current and possible future weapon systems and force units and relate these estimates to the costs of similar past systems and units. These analysts must be organizationally placed to allow objective analysis and access to the decision-making process.

d. The grade structure for the cost analysts that will allow the acquisition and retention of analysts within the program in an economic environment that is now, and is expected to be, highly competitive.

e. Through a,b,c, and d the capability to produce consistent, accurate and timely estimates of the total resource implications associated with major force unit or weapon system oriented decisions." *

To describe the universe of cost analysis it is necessary to draw a clear distinction between the technical processes of cost analysis and cost estimating and the cost analysis activity or function, as described above.

I-2-a The Cost Analysis and Cost Estimating Processes

This handbook establishes two clearly related, but distinctive processes:

- Cost Analysis- The process of review and evaluation of cost data and the reduction of the complex cost data into simpler and more basic expressions which may be used for purposes of comparison, validation, or estimation.

- Cost Estimating - The process of producing a statement of approximate cost to be incurred in the conduct of an activity such as a project, contract, period of time, etc.

*Note: (Underlining added).

Basically, the cost analysis process involves the review, evaluation and reduction of cost information obtained from any source such as contract cost reports, cost proposals, cost estimates, etc. Included in this process is the construction of cost estimating relationships (CERs). The cost estimating process involves the production of a cost estimate utilizing the data and CERs derived in the cost analysis process and from other sources, as necessary.

It is readily apparent that a cost task may include both cost analysis and cost estimating processes, and, consequently, it is difficult to establish the functional position of Cost Analyst or Cost Estimator. Commonly, the current job title of Cost Analyst identifies a person skilled in both processes. However, throughout this handbook the titles Cost Analyst and Cost Estimator will be used to identify the individual carrying out the particular process.

I-2-b Cost Functions

Organizations are generally structured to conform with the accomplishment of a task or mission and, thus, tend to become rather discipline-oriented in the staff capacities such as accounting, budgeting, contracting, development, procurement. To be effective management tools, cost analysis and cost estimating should be recognized as technical skills which transcend these disciplines and include considerations of goal and objectives in the broad sense and engineering in the narrow sense. Likewise, most managerial levels of decision making have direct effects on costs and are directly affected by the cost analysis and cost estimating process.

For example, although a project manager (or his contracting personnel) may not become directly involved in cost analysis and cost estimating, as presented in this handbook, he:

- Determines (or passes on) the requirements to be written into the contract.
- Has responsibility for negotiating the contract.
- Implements the discipline oriented reporting systems such as cost, schedule, progress, and technical and utilizes their outputs.

In his role as project manager, he must have an up-to-date knowledge of the current project position and the near and long term status of project requirements. These managerial functions not only affect costs, but also make use of detailed cost analysis and cost estimating as one vital part of the management process.

Use of detailed cost analysis and cost estimating in project management benefits the project and also improves the accuracy and validity of the cost processes by their utilization in an environment where there is a high degree of personal responsibility.

I-2-c Cost Information

Cost analyses and cost estimates are derived from basic information of diverse natures. In this handbook we define cost information as any intelligence which reflects or affects (1) the magnitude of an expenditure or resources or (2) the credibility of a source document containing such intelligence.

Cost information is categorized in four groups to facilitate the gathering, analysis, and utilization of cost information:

1. Product Characteristics - This category includes the complete description of the item. These descriptions are further categorized as technical, physical, performance, and mission characteristics.

2. Schedule - This category includes the quantity of items and the production schedule. Typical production schedule events are:
   Production Release Dates
   Delivery Dates
   Production Line Position

3. Resource Expenditure - This category includes the input resources or factors used to develop, test, produce, and/or operate the item being considered. Included are such "inputs" as labor, materials, and capital investment. Common denominators usually are in terms of dollars or manhours.

4. Cost Document Status - This category includes narrative statements of the conditions under which the cost document was prepared and the degree of fiscal responsibility which was implied with the acceptance of the document. For example, the execution of a cost plus fixed fee contract by a contractor does not carry the same level of fiscal responsibility as execution of a firm fixed price contract, nor does an estimate made in a special study carry the same level of fiscal responsibility as a contract proposal.

I-2-d Basic Aspects of Cost

The term "cost" can mean different things to different people, but in cost estimating and cost analysis, the definitions must be precise and uniformly applied.

There are two basic aspects of costs which must be recognized and uniformly defined as a prerequisite for meaningful communication of analyses and estimates. These are:

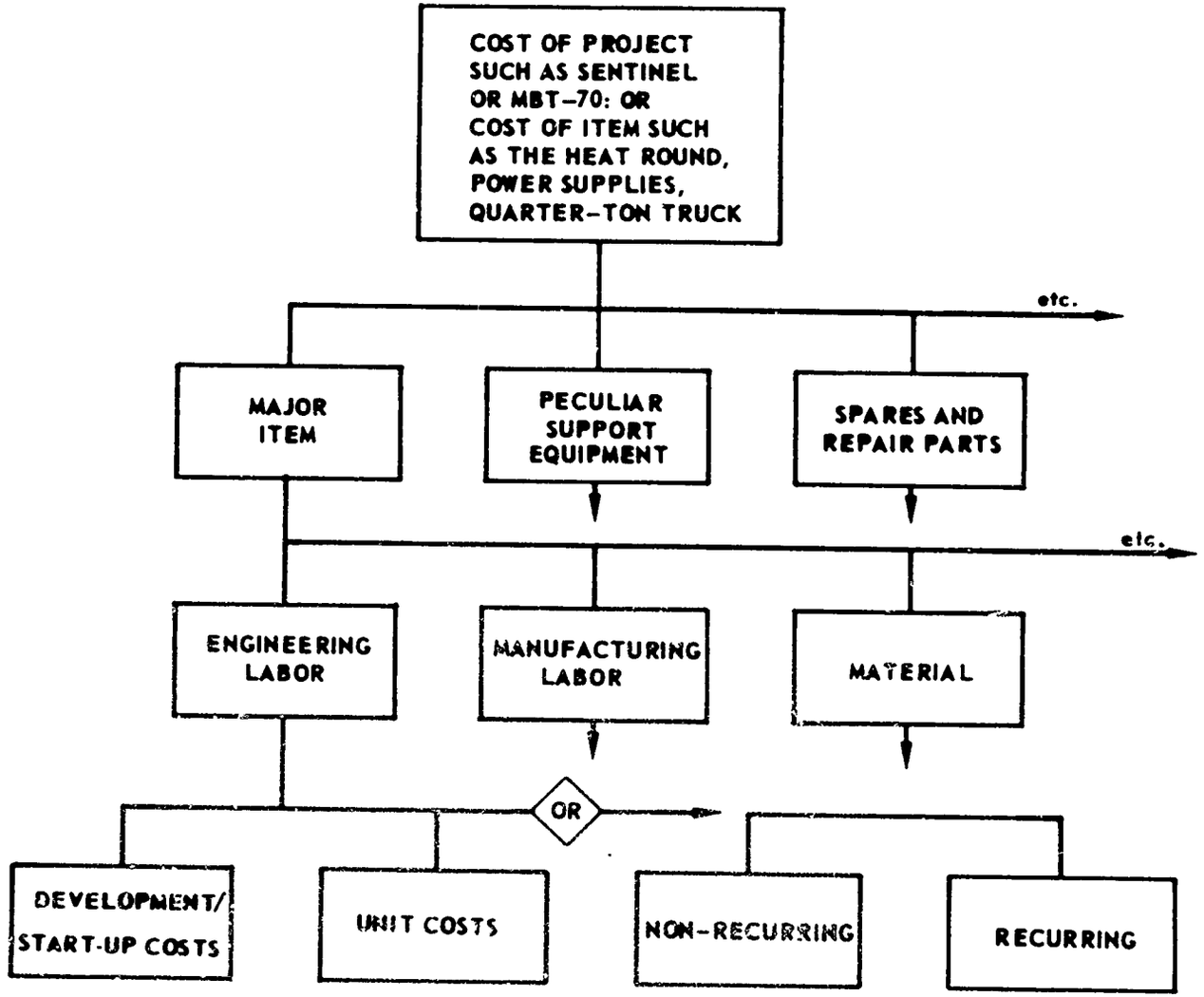
- Generic cost strata for defining the level at which the task is being addressed.
- The bases for placing the costs in the context of time.

Four generic strata utilized in the cost processes are shown in Exhibit I-2. Within these generic strata there may exist substrata which are significant for some applications in the cost processes. There are also special aggregations above these strata, such as the sum of the total costs which is the highest stratum. This total cost is normally documented in the Project Management Master Plan (PM^2P), and budget requests. Such a cost is the summation of the subordinate cost estimates made in lower levels of the strata. As a summation, many of the peculiarities of the item or project will not be evident; therefore, both the cost estimate and the supporting and subsequent cost analyses should be addressed at the lower strata.

In the Work Breakdown Structure (WBS) stratum, the total item is broken out into its component elements or pieces which are considered significant from the standpoint of the cost analysis or cost estimating task. This Work Breakdown Structure may have as many as ten (10) levels of indenture for some applications (one AMC Main Battle Tank Cost Estimating Task used five (5) levels of indenture). Normally, AMC cost studies address no more than the fifth level.

The Resource Category Structure stratum provides a segregation of costs by the type of resources demanded, such as engineering labor, tooling labor, manufacturing labor, manufacturing materials, overhead, and fee. In the more gross cost estimates, an aggregate total is often used in this stratum. It is necessary to be aware of these details, however, in order to be sure of consistency at the higher strata.

EXHIBIT I – 2
BASIC COST STRATA



The application phase stratum identifies the repetitive nature of a particular task. The most widely used approach to defining the stratum is the recurring/non-recurring breakdown defined as follows:

- Recurring Costs - Costs associated with the repetitive functions performed to produce an operational item.

- Non-Recurring Costs - Costs incurred for efforts of a one time nature required to establish the configuration(s) or the facilities and capabilities necessary to produce the operational item.

This approach addresses itself to defining costs of an additional useful unit. Often, the counting of production units does not begin until after test items have been produced on the assembly line and, as a result, learning associated with these test items is not included in the cost analysis.

As the approach is currently used, the analyst must recognize the implication of learning obtained from the production test items and compensate for it. This leads to some inconsistency where comparisons are being made and where CERs are being constructed.

A second closely related approach is sometimes used which separates costs into design, development and start-up cost (referred to as non-variable* in the remainder of this report) and pre-production and production unit costs (referred to as variable * in the remainder of this report). This approach addresses itself to accounting for all units which in anyway contribute to learning.

These two approaches are closely related, sometimes resulting in confusion, therefore, the cost analysts and cost estimators should be alert to the fact that the two approaches are different and that the data base is often quoted in both terms (sometimes interchangeably). The distinction is important to the cost analyst because the historical data are often found in one or the other format and the analysis will not be accurate unless the precise meaning of the data is clear. Likewise, the cost estimator should be aware of the distinction because he may be required to produce estimates in either format, depending upon the user's needs. For instance, for broad decision making purposes, the recurring/non-recurring is often employed because the user of the data is interested specifically in alternatives related to more or fewer operational items. However, for detailed budgeting and contracting purposes, where a high degree of accuracy is required, the second approach is more appropriate because it can provide a better indication of the effect of learning.

* This should not be confused with the fixed and variable concept used in accounting for application of resources. Thus accounting terms tend to be related more to time and/or rate of production.

The essential difference between these two approaches is the charging of cost to and counting of units (both pre-production and production). The second approach utilizes a very close accounting of all units which contribute to learning or can provide resource expenditure information for cost analysis. The recurring/non-recurring approach allocates pre-production and some production units to non-recurring prior to the derivation of cost/quantity relationships; thus, the count of production units is not as precise.

The number of production units allocated to non-recurring varies between programs and even between analyses of the same program. This inconsistency adds considerably to the uncertainty of cost relationships and can result in major errors being induced into CERs due to lack of precision in cost definitions in addition to the other uncontrollable sources of error.

Exhibit I-3 illustrates the effect of such an allocation. The top line in this exhibit is the production unit cost line which was used as the source of the cost data. This curve had a cost at reference unit of 1.0 and an average learning curve slope of 80% (Wright Learning Curve Theory). Using these data, two allocations of production units to non-recurring cost (three (3) and ten (10) units) were made and the units to the non-recurring effort changed the recurring cost at reference unit roughly 20% (from .77 to .62). Such a variation in the allocation of units to non-recurring is not unusual in aircraft and missile programs. The exhibit shows that the allocation to non-recurring can mean significant differences in estimated costs all the way out to the 1000 unit.

This distinction between these approaches is especially significant under the following conditions:

- Derivation of reference unit costs utilizing data accumulated during the early production phase, that is, less than 1000 units.
- Cost estimating where a significant portion of the production is allocated outside the recurring definition, either to test programs or to other users.
- In any detailed analysis of high cost, relatively low production run items such as missiles and aircraft.

As shown in Exhibit I-4, these two approaches are not inconsistent. The recurring/non-recurring costs can be constructed out of an analysis utilizing the other approach by allocation of test item (all pre-production and those production items which are assigned to the test program) cost to the non-recurring cost category and the remainder of the production unit costs to the recurring cost category.

EXHIBIT 1-3

TYPICAL DERIVATION OF RECURRING COST AT REFERENCE UNIT

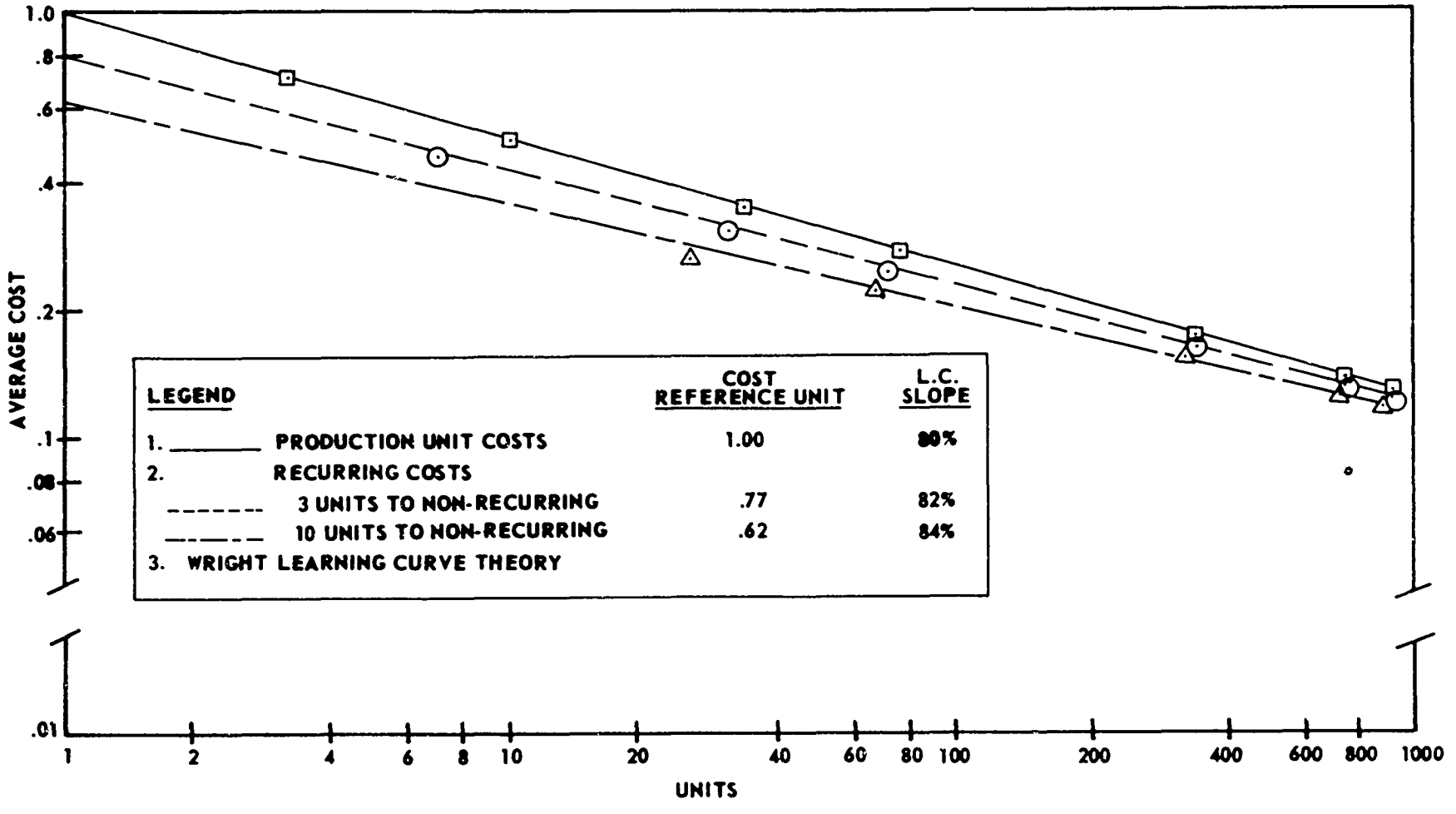
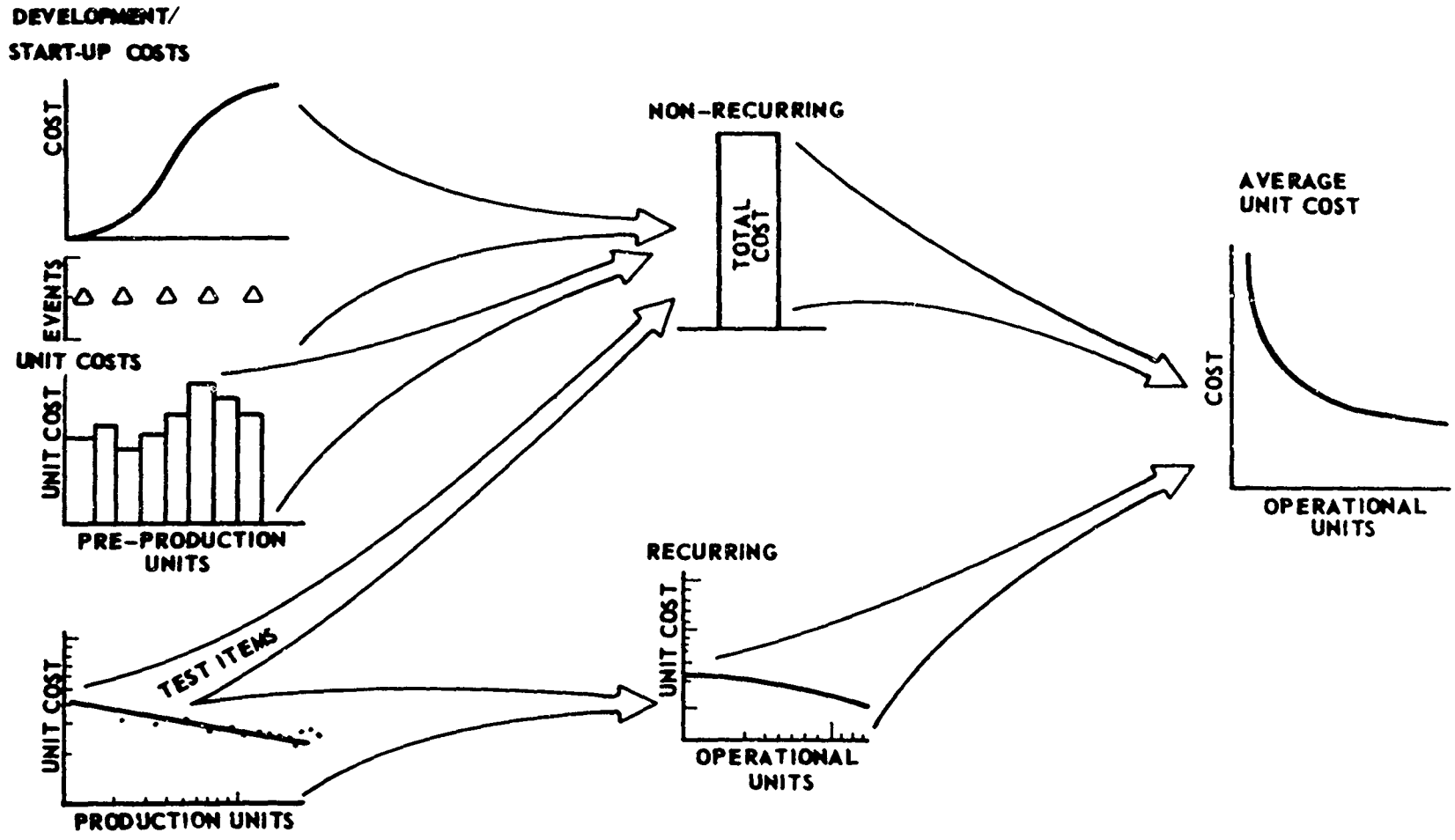


EXHIBIT I – 4

FORMULATION OF RECURRING/NON-RECURRING COSTS



Together, then, the summation of non-recurring and recurring costs can provide inputs to an average unit cost of the operational units as is sometimes used in cost-effectiveness analyses.

Similarly, it is important to have cost definitions which facilitate their identification in the context of time, since most cost records have an implicit time phasing. For example, projects are funded in yearly increments; obligations are incurred on another time basis; accounting records accumulate costs by accounting period, etc. At present, there are seven bases for placing costs in the context of time. Each of these is significant because the data available to a cost analyst may be quoted on any one of these bases and the cost estimator may be required to present costs on any of these bases. The major time phasing bases (See Section IV-4) are:

- Government Obligation Authority
- Contract Obligation Authority
- Government Applied Cost
- Contractor Applied Cost
- Government Disbursements
- Contractor Disbursements
- Delivery Cost

The first six of these bases have a time phasing which is different for government and contractor. The seventh, delivery cost, which has been developed for operational convenience in cost analysis and cost estimating, has the same time phasing for both.

I-2-e Construction of a Cost Estimating Relationship (CER)

As an example of how these information categories function in cost work, consider the derivation of a cost estimating relationship. Exhibit I-5 presents, in a simplified flow, the derivation of basic cost numbers.

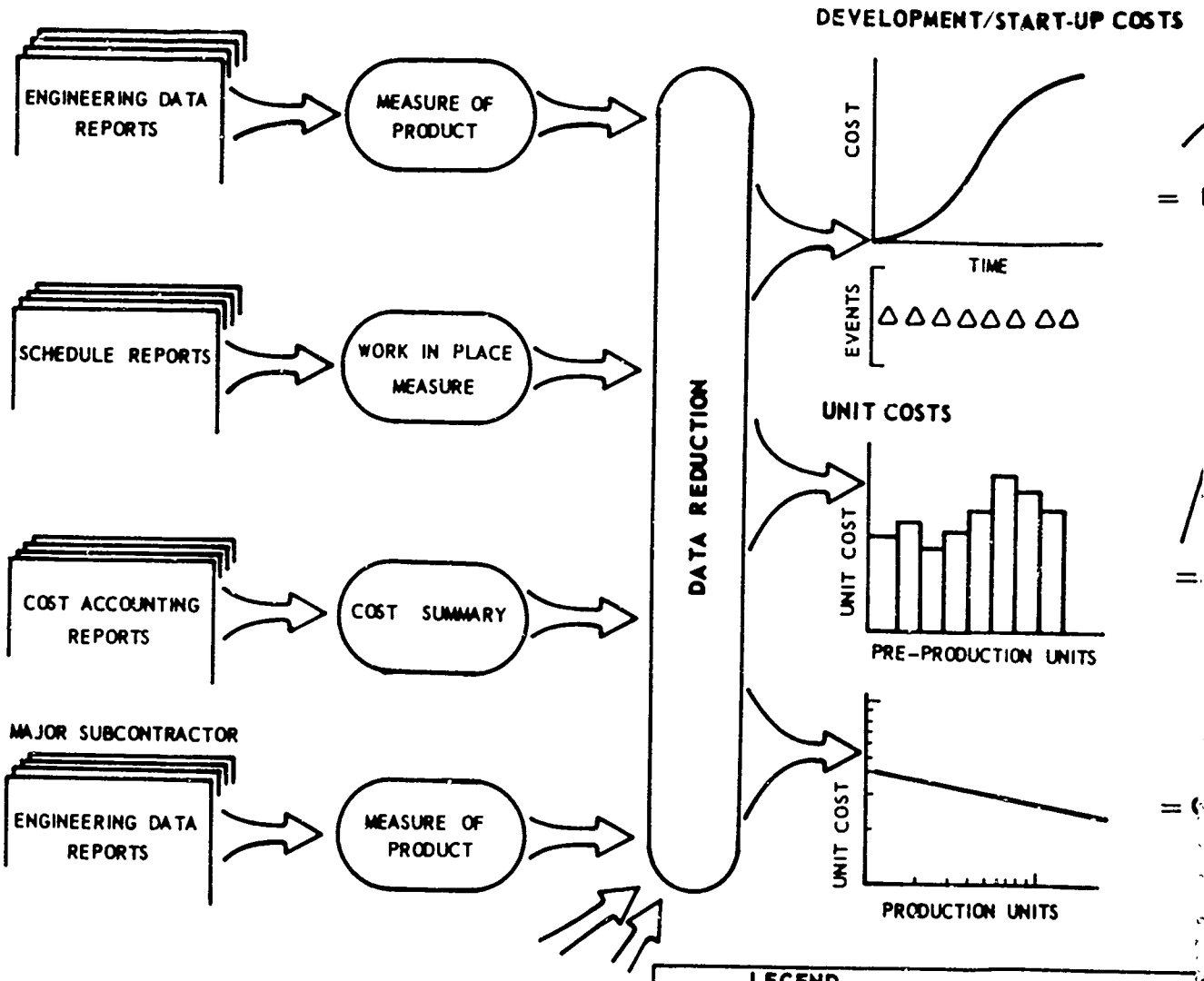
Beginning with the various reports shown in basic data in Exhibit I-5, the cost analyst reviews and evaluates the costs in a data reduction process, shown as the computational regime in Exhibit I-5, to develop relationships of non-variable cost to time and of variable costs to quantity. There are variable costs (materials, direct labor, etc.) for pre-production units (prototypes, test models, etc.) as well as for production units.

The pre-production costs are further reduced so as to yield a statement of each. The non-variable and variable pre-production costs are shown as K_{nv}

BASIC DATA

COMPUTATIONAL REGIME

PRODUCT BY PRIMI



LEGEND

K_{NV} = DEVELOPMENT/START-UP COSTS

K_{V1} = PRE-PRODUCTION COST

K_{V2} = PRODUCTION COST AT UNIT 1

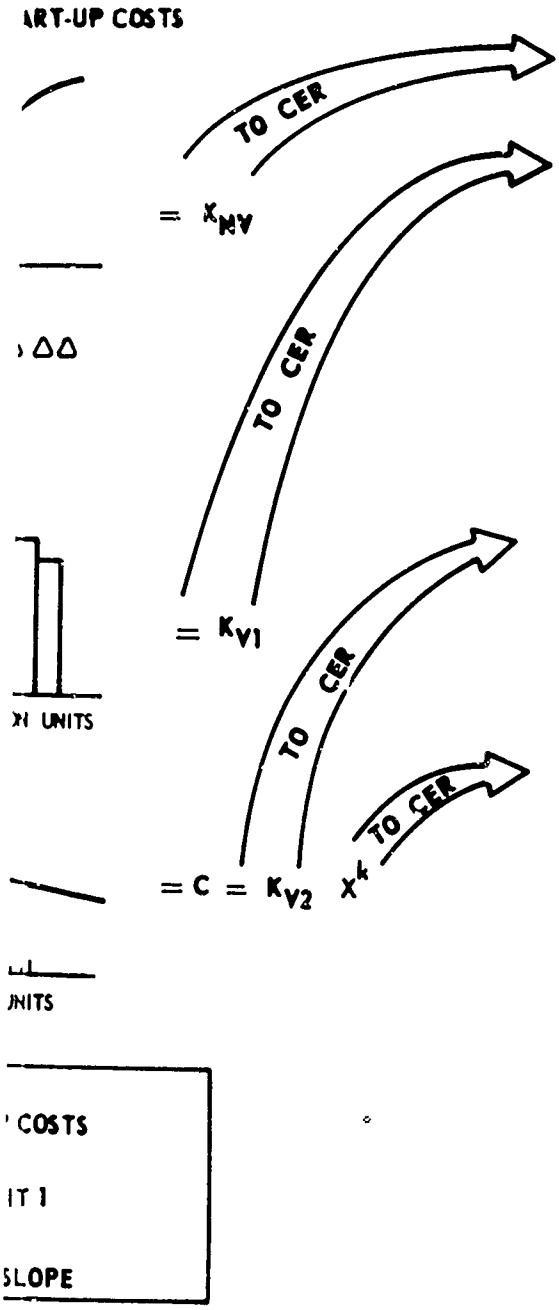
X = PRODUCTION UNIT

k = PROGRESS CURVE UNIT SLOPE

A

PRODUCT RELATED COST
BY PRIME AND SUBCONTRACTOR

COST ESTIMATING RELATIONSHIP



TYPICAL
CER

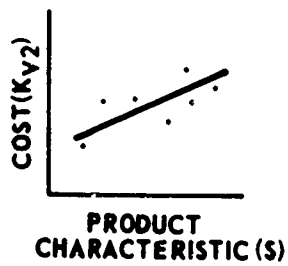


EXHIBIT I-5
TYPICAL COST ESTIMATING RELATIONSHIP DERIVATION

B

and Kv_1 * respectively, under product related cost. For the production costs, a learning curve is fitted to the "unit cost versus quantity" plot and the equivalent cost of a reference unit (shown as Kv_2 in Exhibit I-4) is obtained. In Exhibit I-4, C is a statement of the variable production cost at any unit X.

These cost indicators are then associated with product characteristics of the specific item to provide a single point used in developing cost estimating relationships (CERs).

The above cost statements and product characteristics are obtained for a number of analogous items by following the flow shown in Exhibit I-1 for each item. Product characteristics which reflect the significant effects on cost are then selected. Plots of "cost versus product characteristics" are then developed for each of the non-variable costs, the variable (pre-production) costs, and the variable (reference unit) production cost. A curve is fitted to each of the plots and the equations of these fitted curves are used as CERs to estimate costs of future items when their product characteristics' values are know. (See Chapter III).

I-3 THE COST ESTIMATING SEQUENCE AND PERSPECTIVE

While the major portion of this handbook concerns itself with the conduct of cost analyses and creation of cost estimates (such as the cost analysis procedures and estimating techniques and procedures) it is important initially to know the expected utilization of the end product and the environment within which cost information is generated and cost analyses and cost estimates are utilized. Chapter II, which discusses the "Cost Estimating Framework," is devoted to a description of this environment.

Chapters III and IV outline the methods for conducting cost tasks and present approaches to validation documentation and presentation of cost analyses and cost estimates. These chapters introduce the concept of working reports to back up the summary presentations for each process.

Chapter V follows the detailed discussion of technique with an identification of the steps involved in accomplishing a cost estimate. It discusses the considerations in selecting the level of estimating detail and introduces the concept of cost sensitivity analysis. It also presents the major events in a cost estimating task.

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*Note: The variable pre-production cost may be stated in a cost/quantity relationship rather than as the total cost Kv_1.

I-3, The Cost Estimating Sequence and Perspective

Chapter VI identifies the many offices which have responsibility for generation of cost estimates and cost analyses and presents a discussion of the organizational implications of the conduct of cost analysis and cost estimating in the AMC Comptroller/Director of Programs organization.

Chapter II

ARMY MATERIEL COMMAND COST ESTIMATING FRAMEWORK

This chapter presents the framework within which cost estimates are accomplished and utilized. This framework is a closely interrelated and overlapping structure which has been separated into sequential flows as they occur in the life of a typical project; first, in the case of a project which encounters no difficulties and then indicating the possible effects of the difficulties during a project. To facilitate this discussion two basic functional areas within which cost estimates are utilized are introduced:

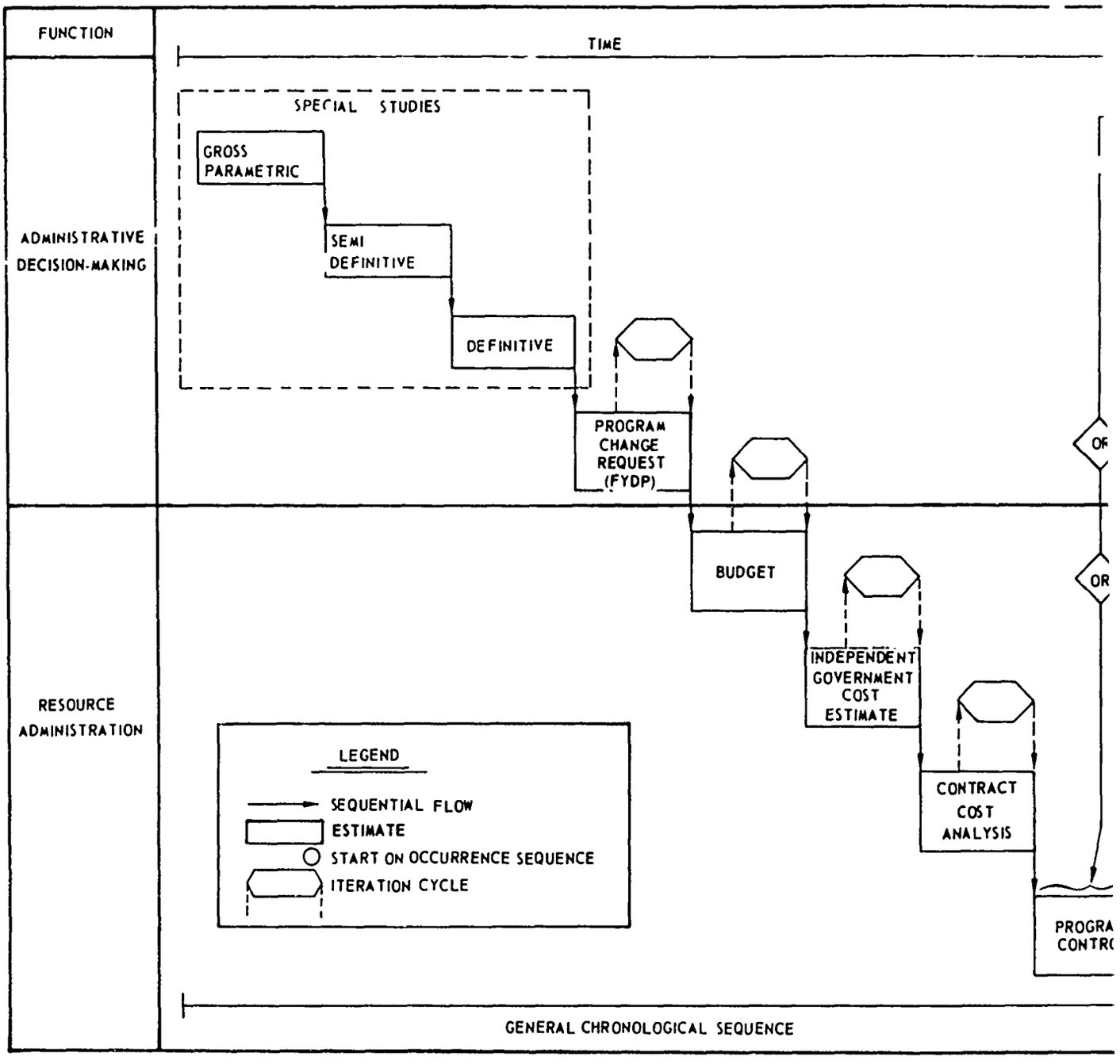
- Administrative-Decision Making Function

  This function encompasses the internal DoD planning activities. The highest order, formalized system in this function area is the OSD Five Year Defense Program (FYDP). Procurement of Equipment and Missiles, Army (PEMA) Management Accounting and Reporting System (PEMARS) (Ref II-1) identifies a function quite similar to this as the "Army Program System."

- Resource Administration Function

  This function encompasses the DoD activities which are defined in law (or administrative regulations and practices). They extend the budget request through the contracting cycle and, subsequently, the expenditure of funds. PEMARS identifies a function quite similar to this as the "Army Control System."

Exhibit II-1 presents a sequential flow of cost estimates. This flow is initiated in the rather ill defined area where someone has an idea for the project. By drawing analogies from similar or related projects, he may perform a very rough (gross parametric cost-effectiveness) analysis to determine if the idea is worthy of further efforts. As these analyses progress through time and through the steps within the basic functions more knowledge is gained about the project and more definitive cost estimates can be made. Of particular interest in this flow is the relatively orderly fall back existing at all levels except from program control. Here, conservative cost estimates, which have passed through the preceding chain, are uncovered by indicated (or actual) overruns which could jeopardize the entire program. The estimates presented in this flow are performed by many staff offices.


FUNCTION
TIME
ADMINISTRATIVE DECISION-MAKING
SPECIAL STUDIES
GROSS PARAMETRIC
SEMI DEFINITIVE
DEFINITIVE
PROGRAM CHANGE REQUEST (FYDP)
OR
RESOURCE ADMINISTRATION
BUDGET
OR
INDEPENDENT GOVERNMENT COST ESTIMATE
CONTRACT COST ANALYSIS
PROGRA CONTRO
LEGEND
SEQUENTIAL FLOW
ESTIMATE
START ON OCCURRENCE SEQUENCE
ITERATION CYCLE
GENERAL CHRONOLOGICAL SEQUENCE

A

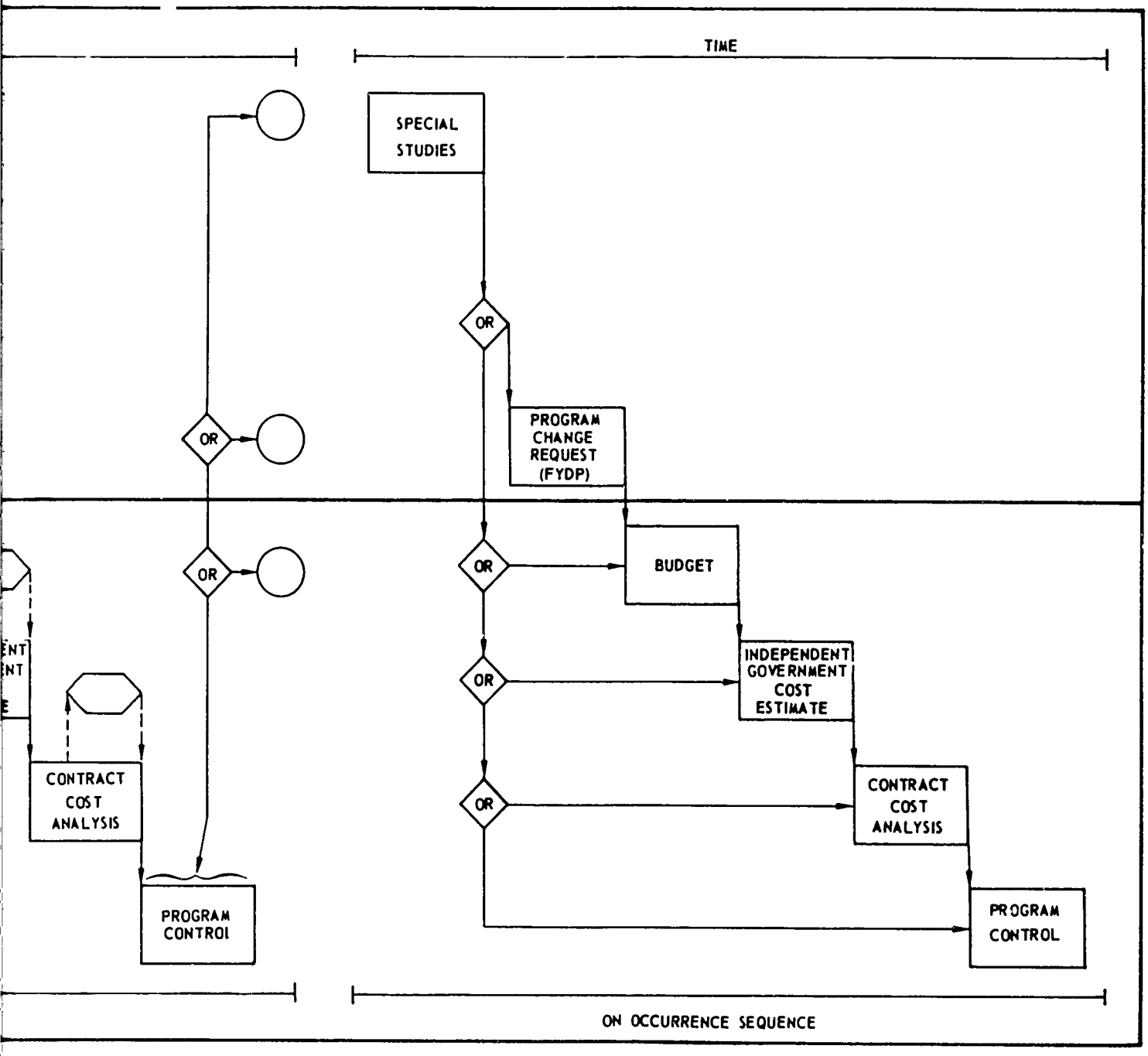


EXHIBIT II-1

CHRONOLOGICAL EVOLUTION OF ESTIMATES

B

II-1. ADMINISTRATIVE-DECISION MAKING FUNCTION

The Administrative-Decision Making Function is the least formalized of the two functional areas. This lack of formality is simultaneously its greatest asset and greatest difficulty. Its greatest asset is the freedom it allows in structuring a cost estimate to address the specific problem. Its greatest difficulty is that the burden is placed on the estimator to maintain the capability of translating from the structure used in the specific study to those structures which will be utilized in subsequent steps. The importance of maintaining this freedom in structuring has been recognized by the House of Representatives in the comments on the proposed "Project PRIME":

> "There are a number of pitfalls that can be foreseen with respect to the proposed system (Project PRIME), not the least of which is the flexibility of the program structure which would necessarily follow. At present the program structure, being independent of the budgeting and accounting system, can be altered or redirected as circumstance or prudent management appears to require. Once such a program system becomes legislative history in support of an appropriation act it can be changed only by some further legislative expression. (parentheses added) (Ref. II-2)

Within this function the estimator is given the greatest freedom in the conduct of special studies. As the estimates address problems more closely associated with the Resource Administration Function, the estimator becomes more rigidly constrained by the structure of that function.

II-1-a Special Studies

Special studies may be originated at any level within DoD. Exhibit II-2 presents a characteristic list of special study applications.

EXHIBIT II-2

COST ESTIMATING APPLICATIONS

PLANNING

- Feasibility Analysis
- Worth Analysis
- Alternative Analysis
- System Selection Analysis

BUDGETING

- Program Evaluation
- Proposal Evaluation
- Funding Studies

CONTRACTING

- Design Trade-Off Analysis
- Incentive Analysis
- Incentive Evaluation

MISCELLANEOUS

- Sales Pricing
- Economic Impact Studies
- Technical Impact Studies

These special studies can be classified, on the basis of relative definitive precision required (or provided) for a particular level of estimating, into three strata of cost data, as follows:

- Gross Parametric. Initial cost estimates, particularly those made for the purpose of feasibility analyses, utilize gross parametric cost engineering inputs based on preliminary engineering calculations, sketches, and diagrams. Typically, these will consider broad concepts of power, output, subsystem weights, volumes and associated performance constraints. A working definition of gross parametric estimate is the level useful only in order of magnitude estimates.

- Semi-Definitive. The next level of cost estimate will encompass preliminary estimates, preliminary engineering data and cost data on Government Furnished Equipment (GFE). This level of estimating differs from the gross parametric primarily in the level of detail available on the system or item being costed. This level will consider such configuration elements as electric power generation plant, lighting system, heating system and preliminary spare part estimates. A semi-definitive estimate is relatively advanced, but one in which additional work is needed before contract provisions can be written.

- Definitive. These final estimates are compiled from firm-priced bids, engineering drawings, spare parts lists, and estimates on all supporting services and equipment. These are the estimates upon which the final comparison and decisions can be made and at which comparability and compatibility between cost estimates and actual performance can be established with a high level of confidence. At this level of analysis it is possible to write contract provisions.

For example, where these special studies are to be used as a basis for initiating a Program Change Request (PCR) and may be incorporated into the PCR as backup or substantiating material, a semi-definitive or a definitive cost estimate should be performed. Similarly, for special studies which are to be used to formulate a command position, a semi-definitive or definitive cost estimate should be performed.

Assigning a cost estimate to one of these strata is essentially a subjective judgment reflecting the level of confidence of the cost estimator in the data used in the study.

The level of confidence in the estimate at each stratum will depend upon the approach used to estimating the cost. The four approaches, described more fully in Chapter III, Section 6, "Cost Estimating Techniques" are:

1. Statistical
2. Simple Analogue
3. Engineering
4. Expert Opinion

The statistical approach is generally most desirable, if a significant amount of historical data can be obtained at the desired stratum of cost data. Typically, the statistical approach is used in the gross parametric and semi-definitive strata. When sufficient data are not available, the simple analogue approach is used here.

The engineering approach is most appropriate for the definitive strata. In areas where it is not possible to use any of these three approaches, expert opinion must be utilized in any of the stratum.

The protocol for reviewing special studies is not specifically stated in any set of rules or regulations. These coordination cycles are inferred by the mission and function assignments and are established by practice or precedent. The importance of the coordination (or review) cycle cannot be overemphasized, especially in matters which impinge on command positions or policies.

II-1-b. Programming System

The DoD Programming System was established by the Office of the Secretary of Defense in 1961 to provide a mechanism for analysis and decision-making within the context of a "mission (or output)-oriented" structure.

The basic structure of the Programming System is the Five Year Defense Program which comprises the following ten programs:

II-1, Administrative-Decision Making Function

Program Numbers	Program
I	Strategic Forces
II	General Purpose Forces
III	Intelligence and Communications
IV	Airlift and Sealift
V	Guard and Rescue Forces
VI	Research and Development
VII	Central Supply and Maintenance
VIII	Training, Medical, and other General Personnel Activities
IX	Administration and Associated Activities
X	Assistance

(Ref.II-3)

Typical "mission oriented" program elements, extracted from Program II, General Purpose Forces, and Program VII, Central Supply and Maintenance, are shown in Exhibit II-3.

This structure, which falls within the Administrative-Decision Making Function, is a major management tool for the Secretary of Defense. It is within this context that he presents his annual program to Congress. The presentations within the Resource Administration Function, however, are made by the Defense Comptroller.

As indicated in Exhibit II-1 there is a chronological evolution of estimates. Exhibit II-4 places this evolution in a general context of time and associates it with the project phases. Of particular interest in this flow is the continuity provided by the FYDP which maintains a projection of the defense posture and the project plans for four years beyond that contained in the budget. While this flow is presented in the general context of time, no specific calender can be implied, since the flow from FYDP into budget action and execution may be iterated for a number of fiscal years before the project advances to the next phase.

PROGRAM II
GENERAL PURPOSE FORCES

ELEMENT NUMBER	PROGRAM ELEMENT	ELEMENT NUMBER
2200	FORCES (ARMY)	7100
2210	COMBAT FORCES	7110
2211	DIVISIONS	71111A
22111A	ARMORED DIVISIONS	71112A
22112A	MECHANIZED DIVISIONS	71113A
2212	SEPARATE BRIGADES	7180
22121A	ARMORED BRIGADES	71811A
2213	OTHER COMBAT UNITS	71896A
22131A	ARMORED CAVALRY REGIMENTS	71897A
22132A	MISSILE COMMANDS	71898A
2220	COMBAT SUPPORT FORCES	71899A
2221	FIELD ARTILLERY BATTALIONS	7200
22211A	TARGET ACQUISITION BATTALLIONS	72011A
22213A	HOWITZER BATTALIONS (8 INCH)	72012A
2222	AVIATION UNITS	72013A
22221A	HELICOPTER COMPANIES(LIGHT)	72014A
2224	OTHER COMBAT SUPPORT	72015A
22241A	COMBAT SUPPORT UNITS	72016A
22242A	COMBAT ENGINEER BATTALIONS	72017A
2225	SS MISSILE BATTALIONS	72018A
22251A	LANCE BATTALIONS	72019A
22252A	SERGEANT BATTALIONS	72021A
2230	COMBAT SERVICES SUPPORT FORCES	72022A
22311A	FIELD ARMY SUPPORT	72023A
22312A	THEATRE ARMY SUPPORT	72024A
2300	OTHER SUPPORT (ARMY)	72025A
2310	EUROPE	72028A
23196A	BASE OPERATIONS	72029A
23197A	TRAINING	72033A
23199A	MILITARY FAMILY HOUSING	72034A
2360	OPERATIONAL SYSTEMS DEVELOPMENT	7800
23611A	LITTLE JOHN	78011A
23612A	HONEST JOHN	78012A

(REF II-3)

A

PROGRAM VII
CENTRAL SUPPLY AND MAINTENANCE

ELEMENT NUMBER	PROGRAM ELEMENT
7100	SUPPLY
7110	GENERAL SUPPORT
71111A	SUPPLY DEPOTS/OPERATIONS
71112A	INVENTORY CONTROL POINTS
71113A	OTHER SUPPLY ACTIVITIES
7180	OTHER
71811A	CHANGES IN WORKING CAPITAL
71896A	BASE OPERATIONS
71897A	TRAINING
71898A	COMMAND
71899A	MILITARY FAMILY HOUSING
7200	MAINTENANCE AND SERVICE ACTIVITIES
72011A	AERONAUTICAL MAINTENANCE ACTIVITIES
72012A	REVENUES (AERONAUTICAL MAINTENANCE)
72013A	ARSENALS
72014A	REVENUES (ARSENALS)
72015A	ELECTRONIC AND COMM MAINT ACTIVITIES
72016A	REVENUES (ELECTRONIC AND COMM MAINT ACTIVITIES)
72017A	VEHICLE MAINTENANCE ACTIVITIES
72018A	REVENUES (VEHICLE MAINTENANCE ACTIVITIES)
72019A	OTHER MAINTENANCE ACTIVITIES
72021A	REVENUES (OTHER MAINTENANCE ACTIVITIES)
72022A	ARMY PICTORIAL CENTERS
72023A	REVENUES (ARMY PICTORIAL CENTERS)
72024A	PROVING GROUNDS
72025A	REVENUES (PROVING GROUNDS)
72028A	SHIP MAINTENANCE ACTIVITIES
72029A	REVENUES (SHIP MAINTENANCE ACTIVITIES)
72033A	PRINTING PLANTS
72034A	REVENUES (PRINTING PLANTS)
7800	OTHER
78011A	INDUSTRIAL PREPAREDNESS
78012A	LOGISTICS

EXHIBIT II-3
TYPICAL FIVE YEAR DEFENSE PROGRAM
MISSION ORIENTED ELEMENTS

B

EXHIBIT II-4
TYPICAL PROJECT FLOW

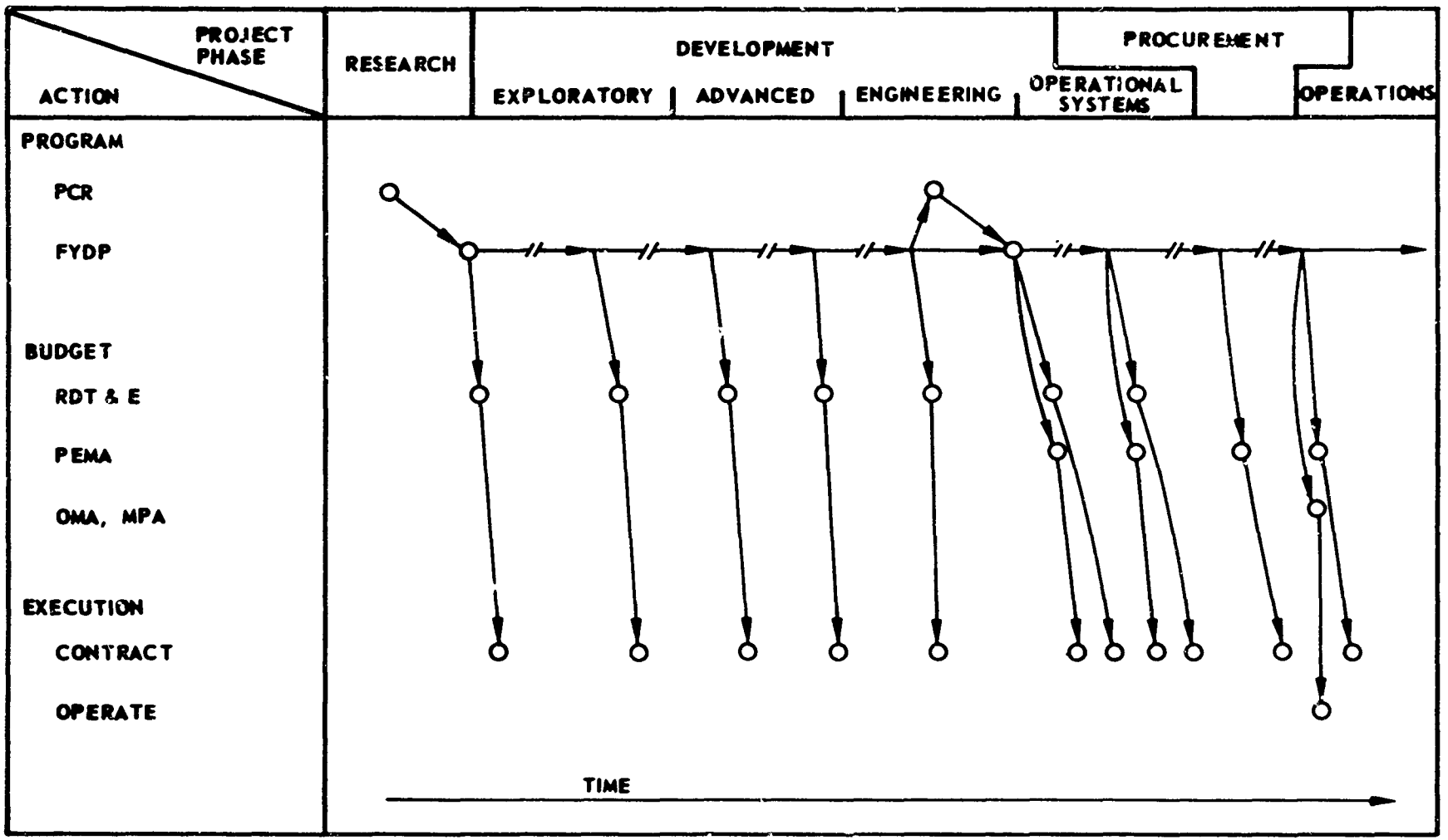


Exhibit II-4 indicates the origination of a Program Change Request (PCR) from basic research (see Reference II-4 for PCR details). This PCR requests authority to place the project in the Five Year Defense Program (FYDP) and proposes a specific level of funding (in current year dollars) for the current year (CY), budget year (BY), program year (BY+1) and three "out" years (BY+2;+3;+4). If this level of funding is adequate and there is no reduction of the program, the next PCR action will occur when an "approval for production" is requested.

This "approval for production" PCR proposes that the developed item be placed in production status. It identifies specific quantities by year for the current year plus five, indicates the PEMA, OMA, and MPA funding and the reallocation of military and civilian personnel spaces, where applicable. If this funding is adequate and there is no program redirection no further PCR's will be required.

The subsequent discussion addresses the Programming System from the viewpoint of actions which occur when a project's status is altered and those which occur within the annual cyclic FYDP actions.

Exhibit II-5 presents selected "On Occurrence" actions directly related to the Programming System. The first, fourth (3A), and seventh (1A) lines present typical catalytic occurrences. The other lines summarize the Administrative-Decision Making reactions.

Exhibit II-6 presents a summary of the organizational actions and reactions which occur in the Administrative-Decision Making/Resource Administration cycle. Exhibit II-7 places these actions into a general context of time. This cycle is shown as a single sequence. A given execution year is also the budgeting year for the next execution year, and the programming year for the subsequent execution year. It should be noted that "On Occurrence" actions have been excluded from this cycle since these can arise at any point in time.

II-1-c. System/Project Management

The System/Project Management procedures (Ref. II-5, II-6, II-7) formalize the requirements for the set of data which must be maintained by the chartered System/Project Manager. This set of data is called the Project Management Master Plan (PM^2P). It is a compilation of individually approved planning documents which place in context the plans, schedules, costs, technical parameters and scope of the project. Thus, the PM^2P is the focal point at which the current status of the program is brought together. This procedure falls in both the Administrative-Decision Making and the Resource Administration Functions.

	ACTION	FLOW	SECRETARY OF ARMY/OSD/ETC	CHIEF OF STAFF, ARMY
1	Requirements - force structure, time phased installation of equipment new research and development, redirected R & D efforts	→		Analyzes National Security Policy Nation Defense Posture, Army Position, etc. Develops Army force structure, and time phasing equipment requirements. Issues: Program objectives for installed equipment, and R & D, Identifies items.
2	Acquisition plans – requirements extended to include development plan, backup units, support units, training requirement, etc Plan for acquiring stated requirements	↓		Reviews
3	Approval	↓		Approves
3a	Directed PCR	→	Directs formulation of PCR	Reviews for reclama action, if appropriate Forwards to cognizant command
4	Programs – PCR only	↓		Reviews and forwards to Sec Army.
5	Approval	↓	Sec Army evaluates and forwards to OSD OSD evaluates, SECDEF acts (Program Change Decision), OSD incorporates into FYDP Sec Army acknowledges, evaluates for reclama action, if appropriate, or incorporates in Army FYDP	Evaluates effect on Army FYDP, evaluates for financial implications and forwards to AMC

1a	Evaluation Actions and events observed at the operating level (AMC/commodity commands) may reveal changes in demand for dollars, schedule changes, quantity implication of force structure changes, etc Personnel at the operating level can initiate actions which result in changes in acquisition plans			

A

IIEF OF STAFF, ARMY	ARMY MATERIEL COMMAND	SUBORDINATE COMMANDS	FLOW
:es National Security Policy, Defense Posture, Army on, etc. ips Army force structure, ne phasing equipment iments. : Program objectives for ed equipment, and R & D; ies items.	Review and abstracts portion, sends info copy to command		
rs	Reviews proposed acquisition plan for technical approach, schedule and cost	Prepares initial proposed acquisition plan, including advanced procurement plan	
res	Reviews for PCR requirement and may prepare PCR; if not, sends action copy to command If no PCR is required, sends info copy to command and includes in next update	Acknowledges, prepares PCR if required	
s for reclama action, if riate Forwards to cog- command.	Reviews and extracts for cognizant offices and commands. Prepares PCR, if appropriate.	Reviews, prepares PCR, as necessary, and adjusts programs.	
s and forwards to ny	Reviews		
tes effect on Army FYDP; tes for financial implica- nd forwards to AMC	Reviews – evaluates effect on program, IF it effects budget on program year – incorporates in budget. IF it effects current year and lacks fund citation, – – THEN AMC initiates contracting action IF NOT THEN AMC adjusts AMC program to release funds, initiates PCR and/or reprogramming action, as necessary	Acknowledges	
	IF evaluation reveals a significant change in schedule, technical characteristics, quantities, funding required, contractor's capabilities, and/or support requirements, and remedial action is within AMC's resources and thresholds – – – THEN AMC has the option of initiating remedial action (informing C/S, A of the situation and action taken); forwarding comments to C/S, A for action; or preparing a PCR. IF NOT THEN AMC will forward comments to C/S, A for action and/or prepare a PCR.		

EXHIBIT II-5

"ON OCCURRENCE" ADMINISTRATIVE ACTIONS

B

	ACTION	FUNCTION	FLOW	SECRETARY OF ARMY/OSD/ETC.	CHIEF OF
1	Update Acquisition plan details for Budget Fiscal Year	Administrative			Review–If updat significant chan characteristics o may revise requi
2	Budget Planning	Administrative			Prepares BY–pro
3	Update FYDP – add new year, adjust economic base, and clean up Budget Fiscal Year	Administrative		Originates ground rules and schedules for program update	Reviews for Army forwards instruc for preparation o
4	Program Review	Administrative		OSD reviews and issues budget guidance	Reviews and con update and forw Army for signatur
5	Budget Guidance	Administrative			Reviews for Army forwards instruct mands for prepara
6	Budgets	Administrative		Reviews, consolidates	Reviews and con
7	Update FYDP–to reflect Presidential Budget	Administrative		Originates gound rules and schedules for program update.	Reviews for Army wards instructio commands for pre
8	Program Review	Administrative		OSD reviews and ajusts as appropriate. This adjustment may be in the form of a directed PCR*	Reviews for Army dates FYDP upda Sec. of Army for
10	Obligation Authority	Resource Administration		Originates budget allocations	Reviews and forw cognizant comma
11	Update FYDP–to reflect Congressional Action	Administrative		Originates ground rules, instructions, and schedules for update.	Reviews for Army wards instruction commands for pre
12	Program Review	Administrative		OSD reviews and adjusts as appropriate. This adjustment may be in the form of a directed PCR*	Reviews, consoli and forwards to S signature
13	Contract Plan	Resource Administration			
14	Contracting Authority	Resource Administration			

*A directed PCR is an "On Occurence" action

A

SD/ETC.	CHIEF OF STAFF, ARMY	ARMY MATERIEL COMMAND	SUBORDINATE COMMANDS	FLOW
	Review–If update reveals a significant change in technical characteristics or in schedule, may revise requirements.	Reviews	Updates acquisition plans for budget year (BY)	
	Prepares BY–program objectives	Reviews, abstracts AMC program	Reviews–estimates budget implications, adjusts command program, prepares PCR and command budget instructions.	
	Reviews for Army impact and forwards instructions to commands for preparation of data.	Reviews and extracts for cognizant offices and commands	Acknowledges	
et	Reviews and consolidates FYDP update and forwards to Sec. of Army for signature.	Reviews, reprices in new current year dollars, prepares PCR, as necessary, adjusts AMC programs within allowable thresholds and adds one year to FYDP		
	Reviews for Army impact, forwards instructions to commands for preparation of data	Reviews and extracts for cognizant offices and commands	Acknowledges	
	Reviews and consolidates	Prepares AMC budget and forwards info copy to commands		
	Reviews for Army impact and forwards instructions to AMC and commands for preparation of data.	Reviews and extracts for cognizant offices, and commands	Acknowledges	
may CR*	Reviews for Army position, consolidates FYDP update, and forwards to Sec. of Army for signature.	Reviews and consolidates AMC position of FYDP	Reviews and prepares PCR as necessary and adjusts programs	
	Reviews and forwards to cognizant commands	Receives obligation authority, allocates it to commands and projects, issues obligation authority to commands	Acknowledges, reclamas where appropriate, adjusts command program, where necessary and sets up FY Books.	
ctions,	Reviews for Army impact and forwards instructions to AMC and commands for preparation of data	Reviews and extracts for cognizant offices, and commands	Acknowledges	
ed	Reviews, consolidates FYDP update, and forwards to Sec. of Army for signature.	Reviews and consolidates AMC FYDP position	Reviews, prepares PCR as necessary, and adjusts command programs.	
		Reviews	Prepares contract plan containing contracting method, RFP, proposal evaluation plan, source selection criteria, draft contract and specifications.	
			Acknowledges and implements contract plan	

EXHIBIT II–6
ADMINISTRATION–DECISION MAKING/RESOURCE ADMINISTRATION CYCLICAL ACTIONS

EXHIBIT II–7

TYPICAL ADMINISTRATIVE–DECISION MAKING/RESOURCE ADMINISTRATION CYCLE

	ACTION	PLANNING YEAR	BUDGETING YEAR	EXECUTION YEAR
1	UPDATE ACQUISITION PLAN DETAILS FOR BUDGET FISCAL YEAR	A		
2	BUDGET PLANNING	A		
3	UPDATE FYDP – ADD NEW YEAR, ADJUST ECONOMIC BASE, AND CLEAN UP BUDGET FISCAL YEAR	A		
4	PROGRAM REVIEW	A		
5	BUDGET GUIDANCE	A		
6	BUDGETS		R	
7	UPDATE FYDP–TO REFLECT PRESIDENTIAL BUDGET		A	
8	PROGRAM REVIEW		A	
9	OBLIGATION AUTHORITY		R	
10	UPDATE FYDP– TO REFLECT CONGRESSIONAL ACTION			A
11	PROGRAM REVIEW			R,A
12	CONTRACT PLAN			R
13	CONTRACTING AUTHORITY			R

A = ADMINISTRATIVE–DECISION MAKING ACTION
R = RESOURCE ADMINISTRATION ACTION

II-2 RESOURCE ADMINISTRATION FUNCTION

The Resource Administration Function is concerned with the translation of the plans and decisions reached in the Administrative-Decision Making Function into funded programs and, subsequently, into accomplished fact. The structure utilized in the Resource Administration Function is dictated by the necessity for complete accountability from the request for obligation authority through contracting, delivery of the items and expenditure of funds. Within this function, the total Army demand for an item to be funded in the budget year is consolidated into a single budget line item for justification and subsequent management of the acquisition. PEMARS (Ref II-1) is the principal designated Army system for accomplishing this Resource Administration Function.

II-2-a. Budgeting.

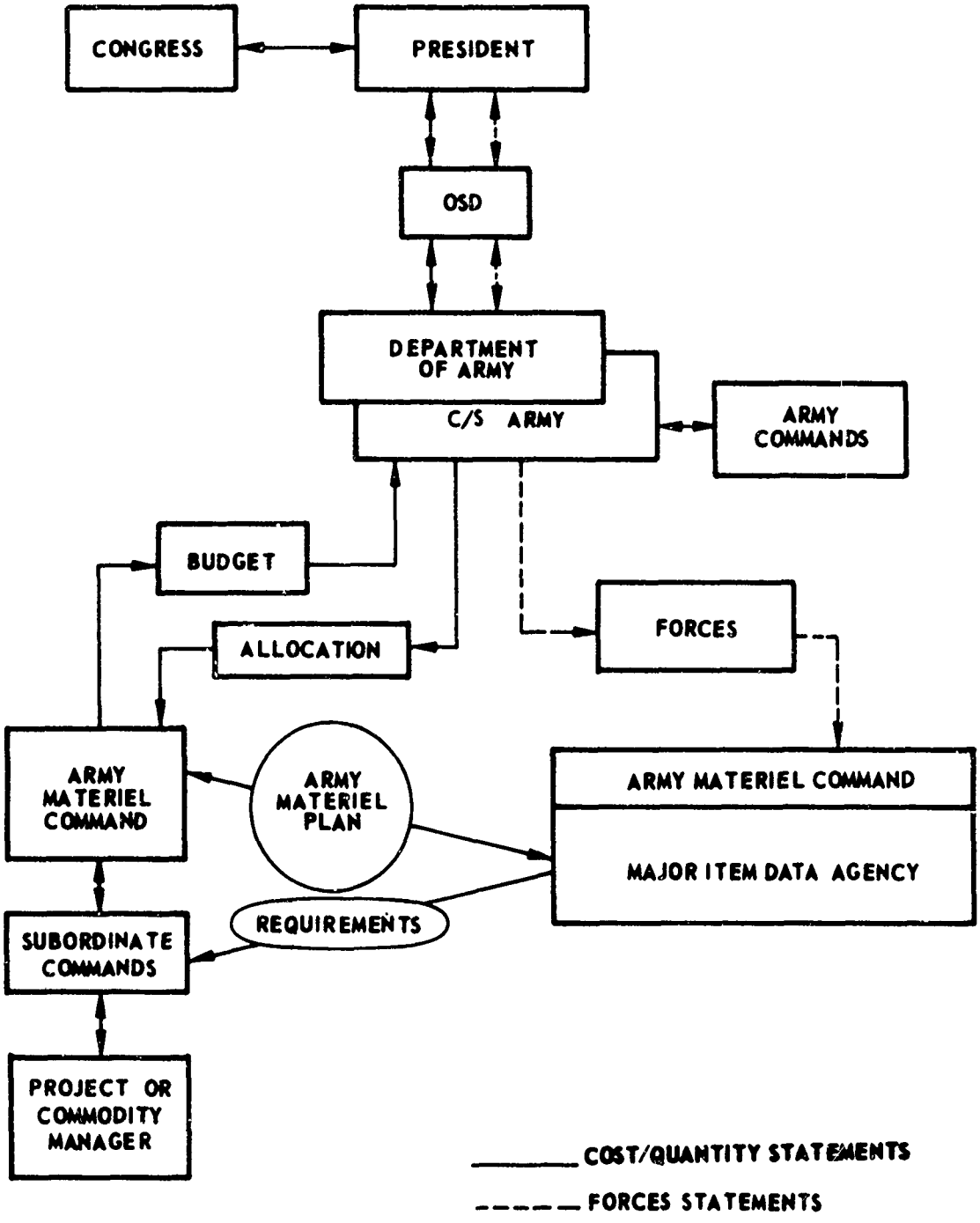
The first step in the Resource Administration phase is the budget. The importance of the budgeting function is emphasized by the following:

> "Budgeting is essentially a decision-demanding process. Therefore, at each echelon performing a budget function, the budget must be reviewed by the commander or officers in charge prior to submission ..... to insure that the request actually represents the decision he has made on the program and budget issues involved." (underlining added) (Ref.II-8)

Entry into the budget is one of the most significant steps in the life cycle of a project or commodity; hence, the budget review is most stringent. As illustrated in Exhibit II-8, a budget line item may face as many as seven detailed reviews. This flow starts at the commodity command level and extends through both Houses of Congress. In each of these reviews the cost, qualitative characteristics, and the quantitative requirements may be questioned.

Once the funds have been appropriated by Congress, the project may face an additional round of justification during the apportionment process. This may be a rather straight forward process of restating past justification. However, this may take the form of a full scale formal rejustification of the item, particularly where across the board budget cuts have been imposed. The cost analysts and estimators must be able to go back into the original estimates made for budgeting purposes and make direct meaningful adjustments before the project can get underway. These adjustments must be carefully documented and supported, for they will form a significant piece of historical data for future cost analysis and cost estimates.

EXHIBIT II-8
TYPICAL BUDGETING FLOW



II-2-b. Independent Government Cost Estimate

The Independent Government Cost Estimate has been implemented by AMC on "all procurement actions wherein the dollar value is expected to exceed one million" (Ref.II-9 and II-10). This detailed estimate should be the most accurate estimate made prior to contract cost analysis (see following paragraph) and should provide a solid basis for that cost analysis.

In addition to supporting a specific procurement action, the data file substantiating this estimate should provide an excellent basis for estimation of the follow on year buys, thus providing a correction factor or validation point for the estimates currently in print or subsequently developed.

II-2-c. Contract Price/Cost Analysis

Upon receipt of a bid or proposal in a negotiated procurement action, the Armed Services Procurement Regulation (ASPR) requires that some form of price or cost analysis be performed. ASPR (Ref. II-11) defines these two analyses as follows:

- "Price Analysis. Price analysis is the process of examining and evaluating a prospective price without evaluation of the separate cost elements and proposed profit of the individual prospective supplier whose price is being evaluated."

- "Cost Analysis. Cost analysis is the review and evaluation of a contractor's cost or pricing data and of the judgmental factors applied in projecting from the data to the estimated costs, in order to form an opinion on the degree to which the contractor's proposed cost represent what performance of the contract should cost, assuming reasonable economy and efficiency."

Prior cost analyses and cost studies, and those accomplished in analogous programs, should facilitate these analyses.

II-2-d. Program Control

The most detailed and stringent cost estimating and cost analysis tasks are those for purposes of program or project control. These cost estimates and cost analyses are accomplished at the level where the maximum amount of detail is available. Also at this level the errors which occurred through all the previous reviews are finally detected, normally, in terms of contract overruns.

These cost analyses and cost estimates, being accomplished from actual contract data sources, can form the most accurate input to the cost data base.

II-3. ARMY MATERIEL COMMAND ORGANIZATIONAL STRUCTURE

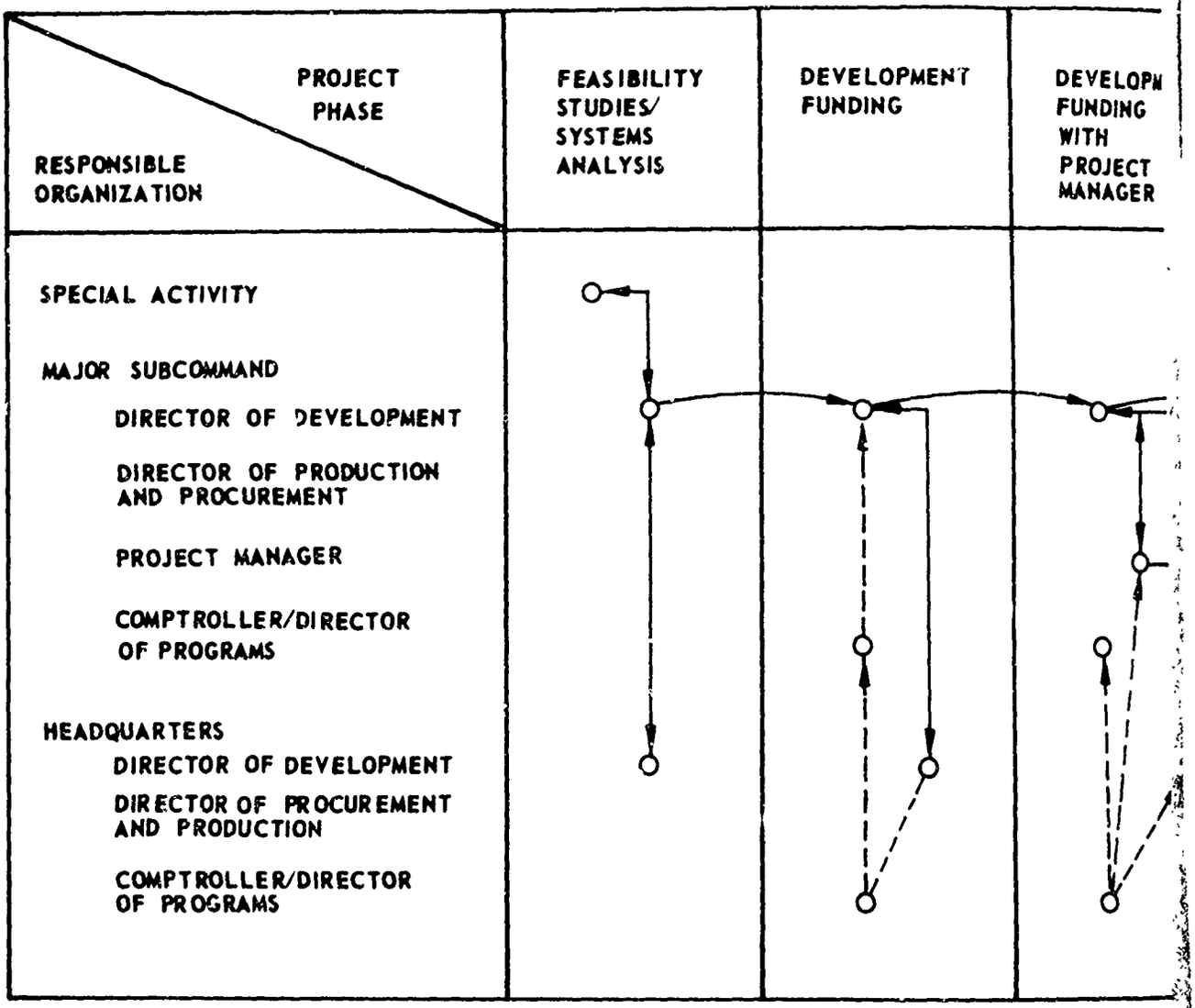
The Army Materiel Command comprises eight major subordinate commands (seven of which are commodity commands) and 32 separate installations and activities. The separate installations and activities support Headquarters, AMC, as well as the major AMC subordinate commands. For example:

- The Major Item Data Agency is the AMC focal point for the ".... asset files reflecting worldwide status of reparable items... and provides... gross requirements and related backup data to the Commanding General, AMC ... and/or the appropriate major commands..." (Ref.II-12)

- Similarly, the Army Materiel System Analysis Center, (AMSAC), was established at the U.S. Army Ballistic Research Laboratories" ... to perform ... independent and effective systems analysis, particulary involving inputs or proposals from more than one commodity area and dealing with major systems or items." (Ref.II-13)

Organizations such as the AMSAC have a continuing requirement for cost estimates, particularly of the "special study" category. The more detailed estimates are normally performed at Headquarters, AMC, or the major subordinate command level.

Cost analyses and cost estimates at the Headquarters and major subordinate command level are accomplished by the Comptroller/Director of Programs, the Director of Development, the Director of Procurement and Production and/or the Project Managers, as appropriate. The division of responsibility among these organizations, as in any large organization, is not always readily delineated in the general sense because of necessarily overlapping involvements in general functions. For example, a project manager must estimate his requirements for funds based on established objectives as an integral part of his managerial function; hence, he must prepare a cost estimate. Concurrently, the Cost Analysis Branch may be estimating similar requirements for the same project in response to a cost estimating task performed for a special study which is looking at alternative objectives. While the division of responsibility at this wider, more general level is not sharply delineated, the responsibility for the specific actions are more readily apparent. Organizational implications are the subject of Chapter VI of the Handbook. A typical sequence of estimates and the organizational responsibilities are shown in Exhibit II-9.



——— ADMINISTRATIVE-DECISION MAKING FLOW

– – – – – FUND RELEASE FLOW

A

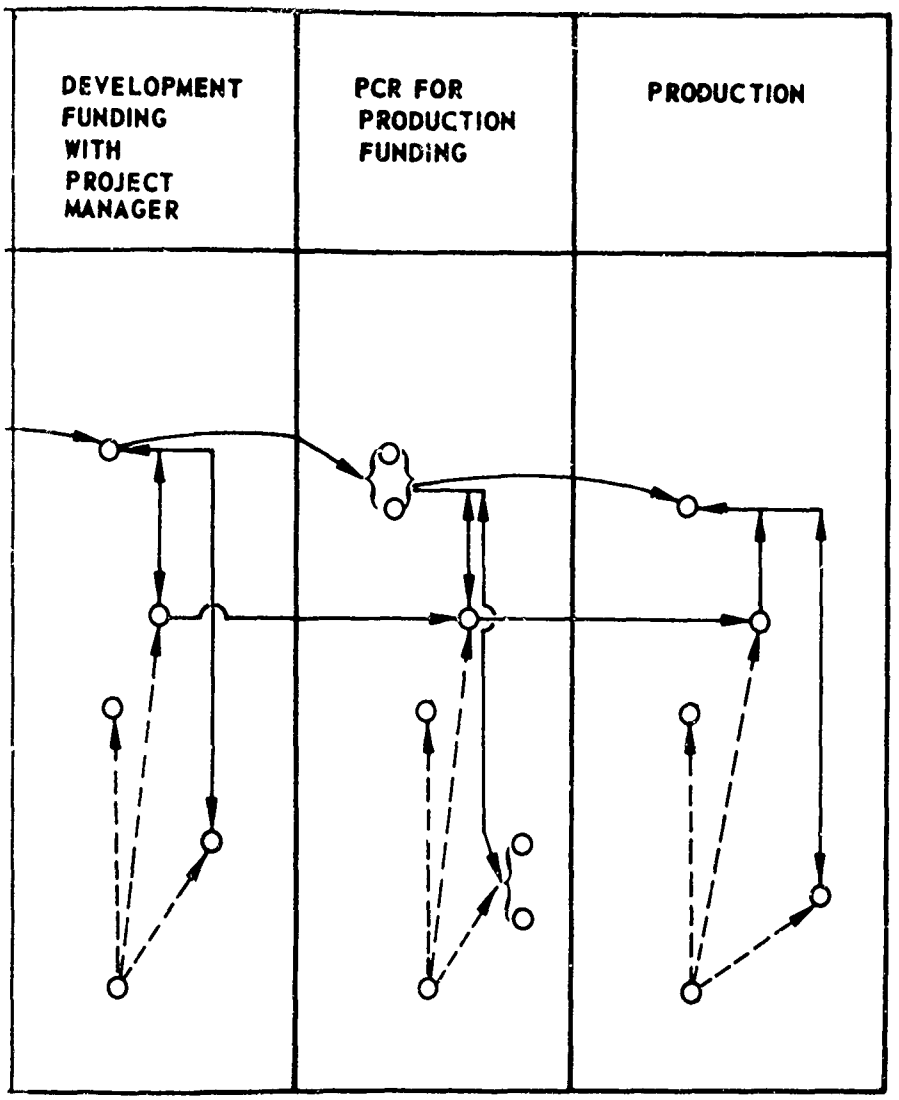


EXHIBIT II-9

TYPICAL ESTIMATING SEQUENCES AND RESPONSIBILITIES

B

The feasibility analyses are conducted by special activities such as AMSAC or possibly as a part of a funded research project. Based on the results of the analyses, the cognizant Director of Development prepares the initial PCR to establish the project in Exploratory Development and staffs it through the Comptroller/Director of Programs and, following approval, repeats the process as a budget item. At some subsequent time a Project Manager may be chartered, introducing a third member to this cost estimating/coordination cycle. (Ref. II-7). The PCR requesting "approval for production" can be a joint effort of the four major subordinate command offices with assistance from the special activities such as AMSAC or the Major Item Data Agency as required. Subsequently, the Director of Development is no longer involved and the other offices continue the cycles.

In equipment procurement, the Army practices (1) centralized commodity procurement and management and (2) projectized management. These two are, to some extent, conflicting practices. For example, Exhibit II-10 presents a summary of AMC Subcommand responsibilities (Ref. II-14).

Superimposed upon this commodity responsibility assignment are the project managers, chartered in accordance with "Research and Development-System/Project Management" Army Regulation 70-17 and its derivations (Ref. II-5 and II-7) who are organizationally distributed as shown in Exhibit II-11. (Ref. II-4)

Within this project/commodity structure, the project manager has the responsibility for funding and managing the project while commodity commands have responsibility for development and procurement of the component items assigned to them. Thus, a commodity command may receive requirements for an item from more than one source, that is more than one project manager, in addition to the more routine demands of the item over which it has direct control.

An example of this interrelationship is the Main Battle Tank Project which is a Headquarters, AMC project. However, actual development, procurement and assembly is to be accomplished by the major subcommands. As shown in Exhibit II-12 it is necessary to go down as low as the fifth level to assign the major subcommand responsibilities, and one of the fifth level WBS elements, Shillelagh Guided Missile, is a project chartered under the same regulations as the Main Battle Tank. (Ref. II-15)

EXHIBIT II-10
COMMAND RESPONSIBILITIES

U.S. ARMY AVIATION MATERIEL COMMAND (AVCOM)

Integrated commodity management of aeronautical and air delivery equipment and of test equipment that is a part of, or used with assigned materiel. Basic and applied research concerning assigned materiel development.

U.S. ARMY ELECTRONICS COMMAND (ECOM)

Integrated commodity management of communications equipment, communications-electronics intelligence equipment, electronic warfare, aviation electronics, combat surveillance, target acquisition and night vision equipment, photographic and microfilming, identification-friend or foe systems; automatic data processing, radar (excluding that used in fire control and fire coordination of air defense systems assigned to another command for management). Meteorological, and electronic radiological detection materiel; assigned batteries and electric power generation equipment; determine vulnerability of army missiles and communications electronic equipment and systems to electronic countermeasures (ECM) and determine requirements for ECM subsystems and techniques to increase Army missile system effectiveness; and test equipment which is a part of, or used with, assigned materiel, and electronic parts and materials common to electronic materiel throughout the Army. Basic and applied research concerning assigned materiel development.

U.S ARMY MISSILE COMMAND (MICOM)

Integrated commodity management of free rockets, guided missiles, ballistic missiles, target missiles, air defense missile fire coordination equipment, related special purpose and multisystem test equipment and test equipment which is a part of, or used with, assigned materiel, missile launching and ground support equipment, missile fire control equipment, and other associated equipment. Basic and applied research concerning assigned materiel development.

U.S. ARMY TANK-AUTOMOTIVE COMMAND (ATAC)

Integrated commodity management of, tactical wheeled and general purpose vehicles and test equipment which is a part of, or used with, assigned materiel. Basic and applied research concerning assigned materiel development.

U.S. ARMY MOBILITY EQUIPMENT COMMAND (MECOM)

Integrated commodity management of surface transportation equipment (other than tactical wheeled and general purpose vehicles); mapping and geodosy equipment for the field armies; assigned electric power generation equipment; construction and services equipment; barrier equipment (including mine warfare and demolitions equipment); bridging and steam-crossing equipment; petroleum handling and dispensing equipment; general support equipment and supplies (fire fighting, industrial engines, heating and air conditioning, water purification, materials handling, etc.); test equipment that is a part of, or used with, assigned materiel. Basic and applied research concerning assigned materiel development.

U.S. ARMY MUNITIONS COMMAND (MUCOM)

Integrated commodity management of nuclear and nonnuclear ammunition; rocket and missile warhead sections; demolition munitions, mines, bombs, grenades, pyrotechnics, boosters, JATO's and gas generators; offensive and defensive chemical and biological materiel; radiological materiel; propellant actuated devices, test equipment that is a part of, or used with, assigned materiel; clips, links, and factory loaded magazines for nonnuclear ammunition; and related components and equipment. Basic and applied research concerning assigned materiel development.

U.S ARMY WEAPONS COMMAND (WECOM)

Integrated commodity management of weapons, including artillary weapons, crew served weapons, and aircraft weapon systems, combat vehicles; fire control equipment (excluding that integral to missile systems and air defense fire coordination systems); common-type tools and common-type tool and shop sets (excluding DSA and GSA items), and test equipment that is a part of, or used with, assigned materiel. Basic and applied research concerning assigned materiel development.

U.S. ARMY TEST & EVALUATION COMMAND (TECOM)*

Engineering (except aircraft performance, stability and control) and service tests and evaluations; support engineer design, production, and post production tests, and participation in troop test planning.

* TECOM does not have commodity management responsibility, hence, is not a commodity command.

EXHIBIT II-11
U.S. ARMY MATERIEL COMMAND PROJECT MANAGERS

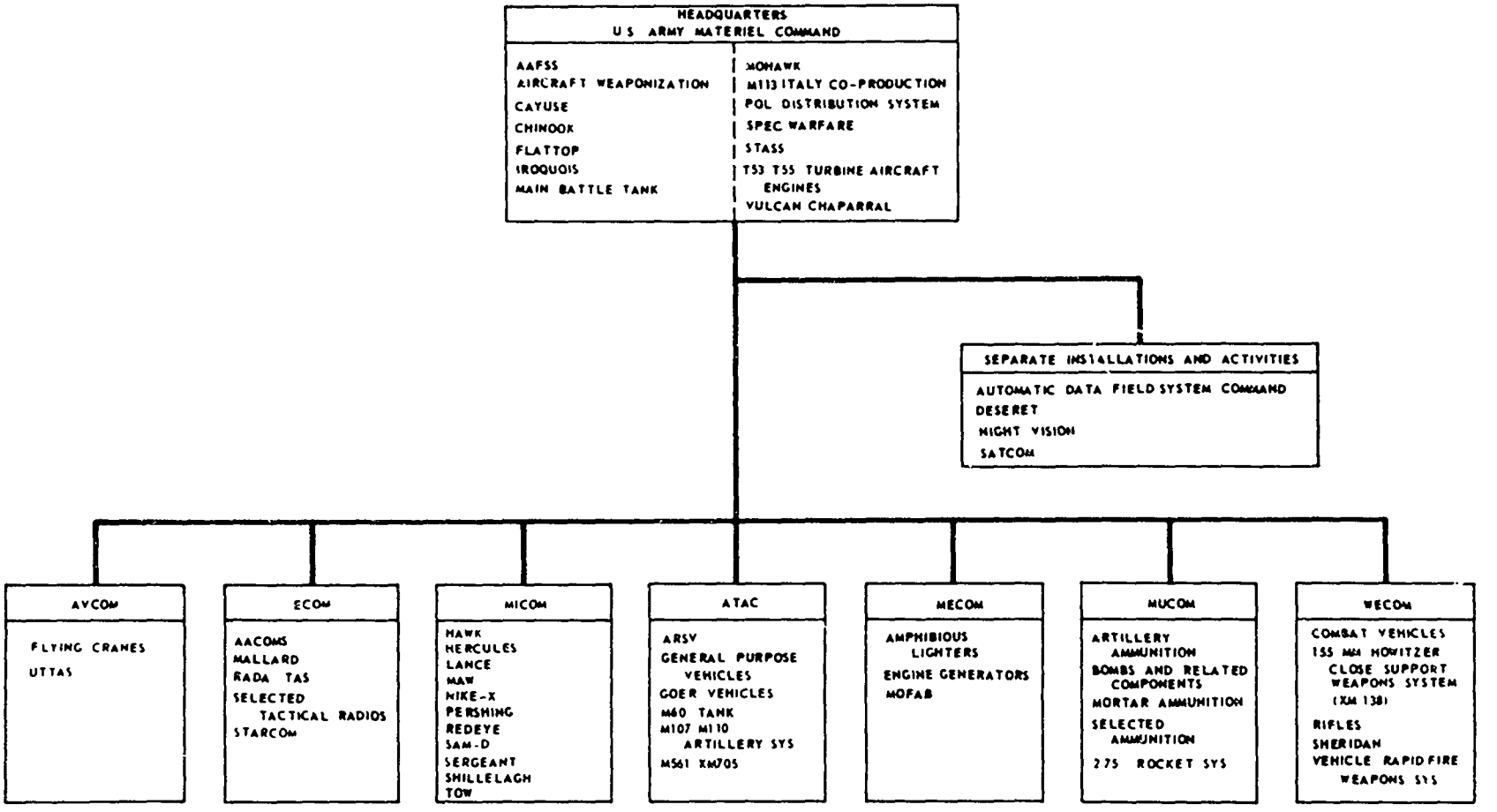


EXHIBIT II-12

MAIN BATTLE TANK WORK BREAKDOWN STRUCTURE WITH IDENTIFIED COMMAND RESPONSIBILITY

WORK BREAKDOWN STRUCTURE LEVEL					RESPONSIBLE COMMAND				
1	2	3	4	5	ATAC	WECOM	ECOM	MICOM	MUCOM
MBT-70 SYSTEM									
	BASIC TANK				x				
		HULL			x				
		SUSPENSION			x				
		POWER TRAIN			x				
		AUTOMOTIVE ELEC			x				
		TURRET COMPLETE							
			TURRET ELECTRIC		x				
			DRIVER'S STATION						
				DRIVER'S ROTATING CAPSULE	x				
				DRIVER'S NIGHT VISION		x			
				DRIVER'S T.V. SYSTEM			x		
				DRIVER'S VISION BLOCKS		x			
				ELECTRICAL SLIP RING	x				
				DRIVING CONTROLS	x				
				INSTRUMENT PANEL	x				
			TURRET COMPONENTS						
				AUTOMATIC LOADER & CONTROLS		x			
				ELECTRO-HYDRAULIC SLIP RING ASSEMBLY	x				
				TURRET STOWAGE	x				
				HATCHES (COMMANDER AND GUNNER)	x				
				TURRET BEARING ASSY	x				
				TURRET STRUCTURE	x				
				SEATS (COMMANDER & GUNNER)	x				
				BASKET ASSEMBLY	x				
				TURRET LOCK	x				
				RADIOLOGICAL SHIELDING	x				
				GUN/TURRET DRIVE SYSTEM	x				
				HYDRAULIC POWER SUPPLY	x				
	ARMAMENT								
		WEAPON MOUNTS							
			PRIMARY WEAPON MOUNTS						
				COAXIAL MACHINE GUN MOUNTS		x			
				TRUNION ASSEMBLY	x				
				RECOIL MECHANISM AND BUFFER		x			
				GUN SHIELD	x				
			GRENADE LAUNCHER MOUNTS			x			
			COMMANDER'S WEAPON MOUNT			x			
		GUN LAUNCHER				x			
		MISSILE GUIDANCE AND CONTROL						x	
		AMMUNITION							
			MAIN AMMUNITION						
				SHILLELAGH GUIDED MISSILE				x	
				KINETIC ENERGY ROUND (XM 578)					x
				HEAT ROUND XM 409					x
				WHITE PHOSPHORUS ROUND (XM410)					x
				BEEHIVE ROUND (XM 617)					x
			SECONDARY AMMUNITION						x
			GRENADE LAUNCHER AMMUNITION						x
			COAXIAL MACHINE GUN AMMUNITION						x
		SECONDARY ARMAMENT				x			
	FIRE CONTROLS								
		CENTRAL EQUIPMENT							
			GUNNER'S FIRE CONTROL						

				KINETIC ENERGY ROUND (XM 578)					x
				HEAT ROUND XM 409					x
				WHITE PHOSPHORUS ROUND (XM410)					x
				BEEHIVE ROUND (XM 6171					x
			SECONDARY AMMUNITION						x
			GRENADE LAUNCHER AMMUNITION						x
			COAXIAL MACHINE GUN AMMUNITION						x
		SECONDARY ARMAMENT				x			
	FIRE CONTROLS								
		CENTRAL EQUIPMENT							
			GUNNER'S FIRE CONTROL SERVO & STABILIZATION ELECTRONICS		x				
			BALLISTIC COMPUTER			x			
			AZIMUTH INDICATOR			x			
			INTERCONNECT CABLING & RELAYS (CDR'S)		x				
			INTERCONNECT CABLING & RELAYS (GUNNER'S)		x				
			400 CYCLE POWER SUPPLY			x			
			COMMUNICATIONS EQUIPMENT INSTALLATION*		x				
		GUNNER'S STATION							
			GUNNER'S NIGHT SIGHT			x			
			GUNNER'S VISION BLOCKS			x			
			GUNNER'S DISPLAY CONTROLS			x			
			GUNNER'S PRIMARY SIGHT			x			
			GUNNER'S AUX SIGHT			x			
			MISSILE TRANSMITTER DRIVE		x				
		COMMANDER'S STATION							
			COMMANDER'S DISPLAYS CONTROLS			x			
			COMMANDER'S NIGHT SIGHT			x			
			COMMANDER'S VISION BLOCKS			x			
			COMMANDER'S PANORAMIC SIGHT			x			
			COMMANDER'S STABILIZATION SYS		x				
	EQUIPMENT								
		STANDARD EQUIPMENT							
			ENVIRONMENTAL CONTROL UNIT		x				
			GAS PARYICULATE FILTER						x
			EC LSS INSTALLATION PARTS		x				
			HUMAN NEEDS		x				
			FIRE EXTINGUISHER SYS.		x				
			BILGE PUMP SYSTEM		x				
		SPECIAL EQUIPMENT							
			WINTERIZATION KIT		x				
			DOZER KIT		x				
			IFF RADAR WARNING DEVICE				x		
			RADIOLOGICAL WARNING				x		
			SEARCHLIGHT SYSTEM						
				SEARCHLIGHT			x		
				SEARCHLIGHT INSTALLATION	x				
			CHEMICAL AND BIOLOGICAL WARNING						x
			NAVIGATIONAL AIDS		x				
			SUBMERGENCE KIT		x				
			WARNING DEVICE LASER I R W L				x		
	OTHER				x				
	INTEGRATION				x				

COMMUNICATIONS EQUIPMENT TREATED AS ON EQUIPMENT MATERIAL

II-3, Army Materiel Command Organizational Structure

Thus, a major subcommand could find, for example, that it is a procuring organization for a budget line item and at the same time procuring the same item in support of a project. Budgeting and cost analysis may be similarly divided.

Exhibit II-13 presents a general computational flow, from the Joint Strategic Objectives Plan (JSOP) through the determination of the PEMA budget request. The computational flow originates out of the JSOP which is treated here as an inviolable objective, as it normally is. However, special circumstances, such as a production slippage or an excessive Total Obligational Authority requirements may require a re-analysis of the JSOP.

The JSOP is taken by the Major Item Data Agency and expanded into its fiscal year procurement implications using data files acquired from the cognizant agencies. The resultant procurement projections are reviewed by the commodity commands and higher headquarters. Where necessary, the computations are to be iterated.

At this point AMC furnishes cost estimates for the procurement projections. Thus, the cost estimates may be directly affected by the JSOP from which the objective is translated into materiel requirements. General materiel requirements are developed at higher headquarters, sometimes by direct statement but more often by implication, while specific itemized materiel requirements are provided by AMC or its subordinate commands.

II-4 CODING STRUCTURE INTERFACES

Coding structure interfaces exist in two dimensions:

- Between discipline-oriented applications

  The term "discipline-oriented" as used herein refers to such "disciplines" as scheduling, program control, engineering, quality assurance, test and evaluation, and accounting.

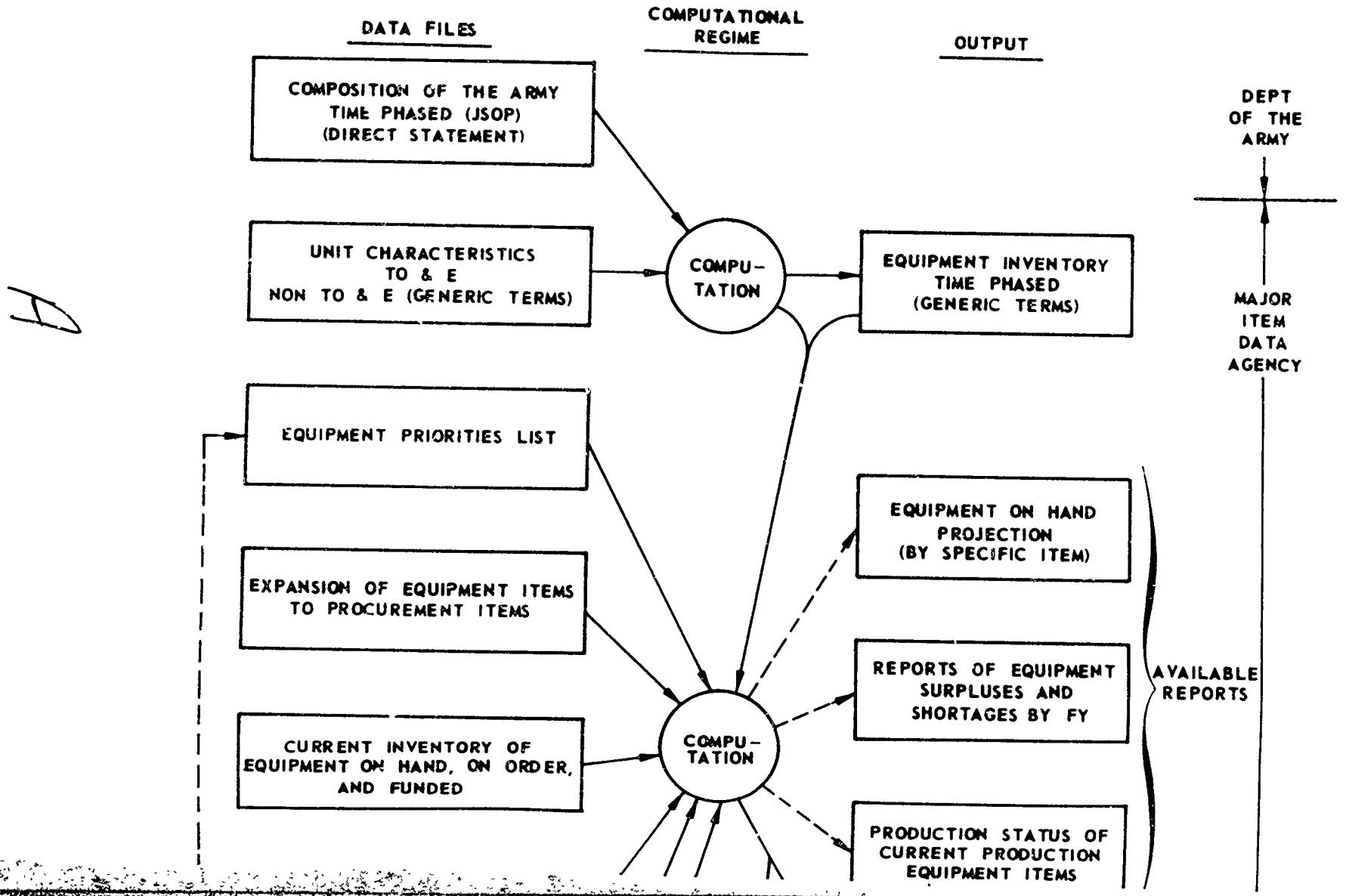
- Between the cost strata

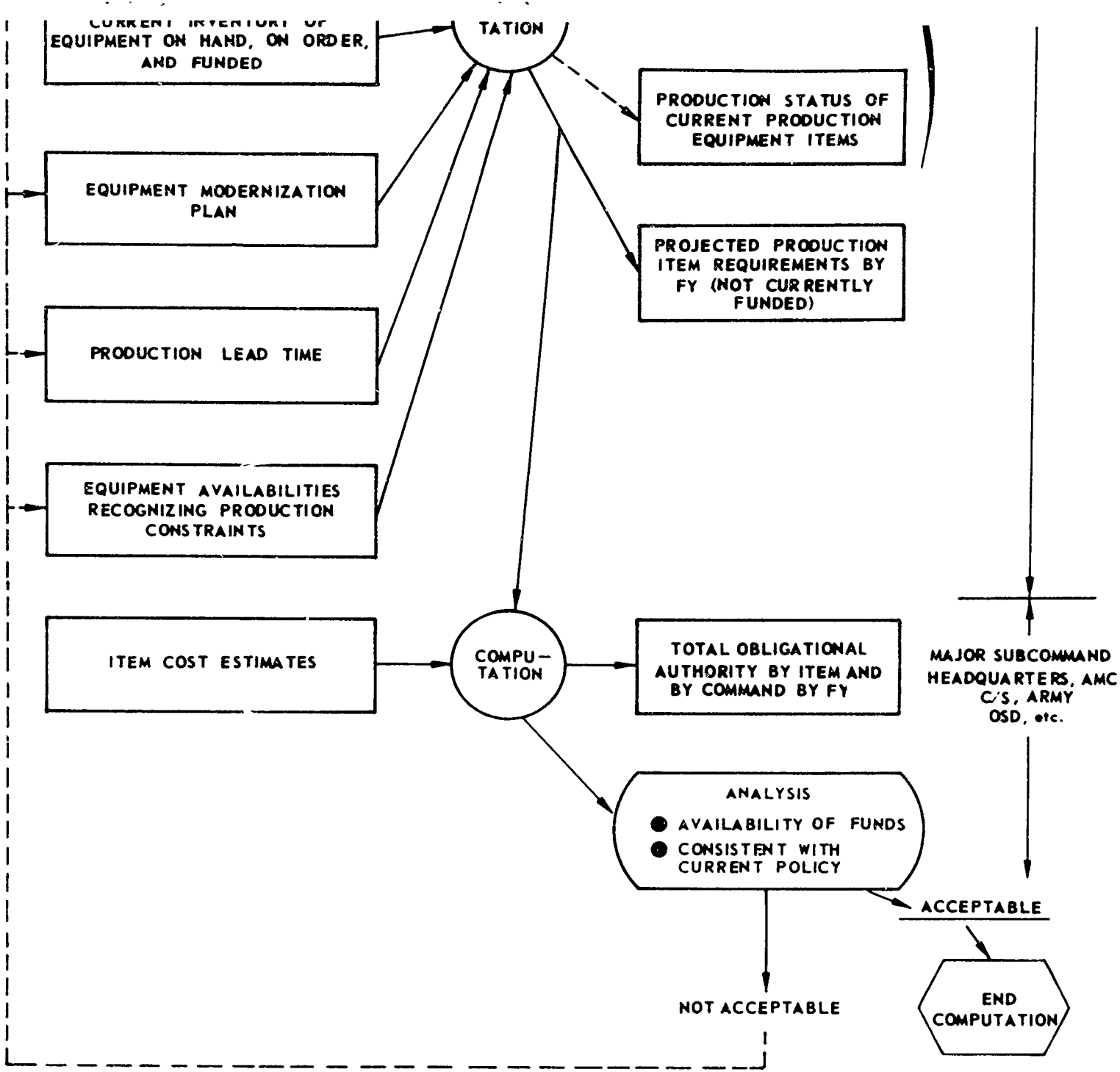
  Between the four basic strata (1) total cost, (2) work breakdown structure, (3) resource category structure and (4) application phase structure presented in section I-2-d.

These two interfaces are discussed below.

EXHIBIT II-13

GENERAL COMPUTATIONAL FLOW




CURRENT INVENTORY OF EQUIPMENT ON HAND, ON ORDER, AND FUNDED
TATION
PRODUCTION STATUS OF CURRENT PRODUCTION EQUIPMENT ITEMS
EQUIPMENT MODERNIZATION PLAN
PROJECTED PRODUCTION ITEM REQUIREMENTS BY FY (NOT CURRENTLY FUNDED)
PRODUCTION LEAD TIME
EQUIPMENT AVAILABILITIES RECOGNIZING PRODUCTION CONSTRAINTS
ITEM COST ESTIMATES
COMPU-TATION
TOTAL OBLIGATIONAL AUTHORITY BY ITEM AND BY COMMAND BY FY
MAJOR SUBCOMMAND HEADQUARTERS, AMC C/S, ARMY OSD, etc.
ANALYSIS
AVAILABILITY OF FUNDS
CONSISTENT WITH CURRENT POLICY
ACCEPTABLE
NOT ACCEPTABLE
END COMPUTATION

II-4-a. Discipline-Oriented Applications

There is an effort within the Department of Defense to develop a Uniform Work Breakdown Structure for Defense Materiel Items. (Ref. II-16 and II-17)

The objectives of this effort are:

> ".... to provide a consistent framework for developing, coordinating, and reporting management responsibility assignments, engineering actions, resource allocation, procurement actions, cost estimates and cost reports throughout the development and production of defense materiel items. Included in this overall objective are the subsidiary objectives to:
>
> A. Unify management techniques which employ or which require information derived from a family-tree type of breakdown.
>
> B. Facilitate technical, programming, and cost comparisons and analyses within a defense materiel item and among several defense materiel items.
>
> C. Provide a guideline for organizational planning of the acquisition of a defense materiel item by the responsible DoD component and their contractors." (Ref II-16)

The current Department of Defense WBS effort is in the formulative stages and when implemented can facilitate improvement in the data base by bringing the existing diversified discipline-oriented applications together below the total contract level. The cost analyst must understand the capabilities and limitations of these discipline-oriented applications which will remain the principle data sources. The WBS provides the capability of relating these sources at a point which reflects a realistic interface/grouping. For example, in a piece of equipment, the characteristics of a defense must be determined within the discipline-oriented system which is structured to interface cost information systems at some specified WBS level.

II-4-a. Discipline-Oriented Applications

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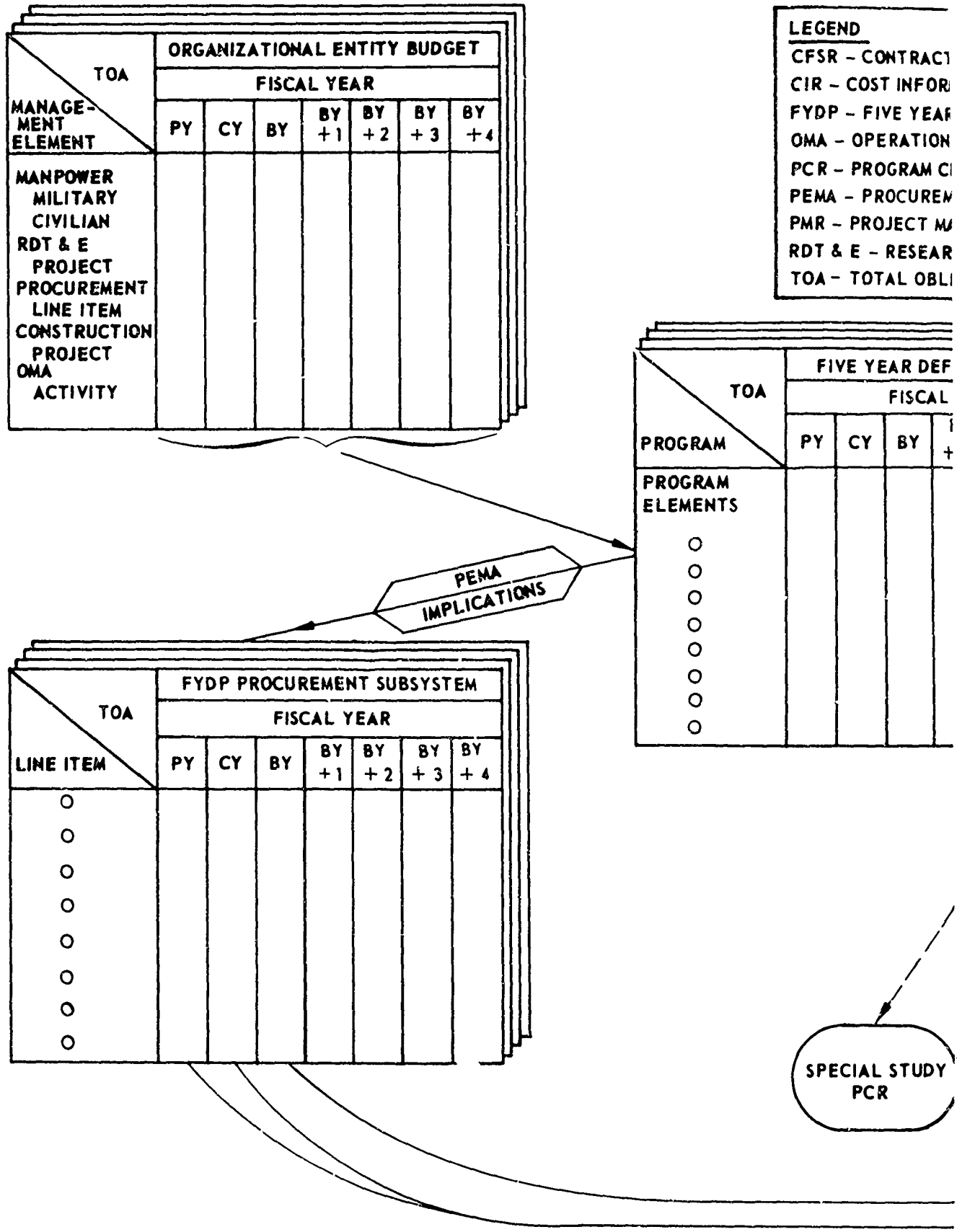

ORGANIZATIONAL ENTITY BUDGET
TOA
MANAGE-MENT ELEMENT
FISCAL YEAR
PY
CY
BY
BY +1
BY +2
BY +3
BY +4
MANPOWER
MILITARY
CIVILIAN
RDT & E
PROJECT
PROCUREMENT
LINE ITEM
CONSTRUCTION
PROJECT
OMA
ACTIVITY
LEGEND
CFSR – CONTRACT
CIR – COST INFOR
FYDP – FIVE YEAR
OMA – OPERATION
PCR – PROGRAM C
PEMA – PROCUREM
PMR – PROJECT M
RDT & E – RESEAR
TOA – TOTAL OBL
FIVE YEAR DEF
FISCAL
PROGRAM
PROGRAM ELEMENTS
PEMA IMPLICATIONS
FYDP PROCUREMENT SUBSYSTEM
LINE ITEM
SPECIAL STUDY PCR

A

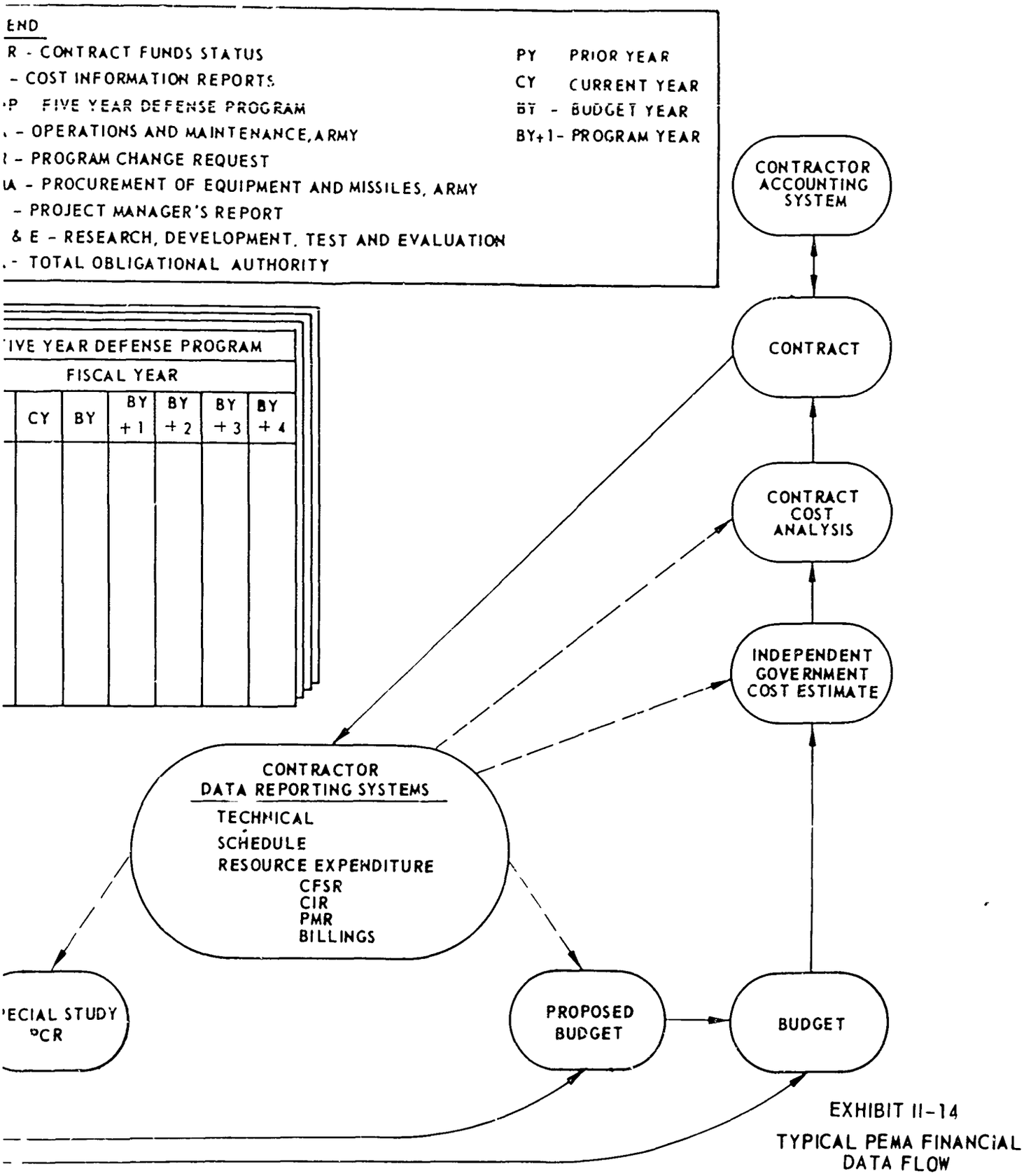


EXHIBIT II-14

TYPICAL PEMA FINANCIAL DATA FLOW

B

activities begin to move from the Administrative-Decision Making Function to the Resource Administration Function, where initiation of funds or fiscal year of funding becomes increasingly important. The specific budgets for prior years and current years and the proposed budget for the coming year are separated from the programming years.

Prior and current year funding have been passed to the commands having obligating authority such as AMC and its subordinate commands. Based on this authority and prior to initiating a procurement, the obligating organization prepares an Independent Government Cost Estimate (Ref.II-9 and II-10) which in turn is used in contract price and cost analyses.

After award of a contract, the contractor is required to report technical and schedule data and may be required to report cost or financial data. The better known cost reporting system is the "Cost Information Reports" (Ref.II-19 and II-20) which has been authorized for aircraft, missile, and space systems and is currently being considered for expansion to electronics, surface vehicles, and ship systems. Exhibit II-15 presents a form typical of the four completed for each designated WBS element. Of particular interest in the description of coding systems are the WBS and the functional categories which provide the basic building blocks for the most detailed estimate. At present there is no official coding system for this level of detail; however, any discussion of coding systems which overlooks this level should be revised.

Exhibit II-16 presents a summary of the major coding structure interfaces.

EXHIBIT II-15
TYPICAL CIR FORM

(SECURITY CLASSIFICATION)

COST INFORMATION REPORT
FUNCTIONAL COST - HOUR REPORT
(Dollars in thous., Hours in thous.)

☐ NON RECURRING ☒ RECURRING ☐ TOTAL

1. PROGRAM: CH-112
2. ☒ CONTRACT ☐ RFP: Nov 64-1234
3. REPORT AS OF: June 30, 1965

Form Approved Budget Bureau No 22-R368

4. MULTIYEAR CONTRACT ☐ YES ☒ NO
FY FUNDED: 64
5. ☐ PRIME ☐ ASSOCIATE ☐ SUBCONTRACTOR (Name and Address, Include ZIP Code): American Mfg. Company, Moline, Illinois
6. NAME OF CUSTOMER (Subcontractor use only):

WORK BREAKDOWN STRUCTURE ELEMENT: AIRFRAME

FUNCTIONAL CATEGORIES	CONTRACTOR		OUTSIDE PRODUCTION AND SERVICES (For Airframe only)		TOTAL	
	TO DATE b	AT COMPLETION c	TO DATE d	AT COMPLETION e	TO DATE f	AT COMPLETION g
1 ENGINEERING						
a DIRECT LABOR HOURS	5.3	9.9	0.8	2.9	6.1	12.8
b DIRECT LABOR DOLLARS	$21.4	$40.7	$ 3.1	$11.5	$24.5	$52.2
c OVERHEAD	36.3	71.0	6.3	23.0	42.6	94.0
d MATERIAL	34.8	90.6	13.2	51.8	48.0	142.4
e OTHER DIRECT CHARGES	1.8	4.7	1.0	4.8	2.8	9.5
f TOTAL	$94.3	$207.0	$23.6	$91.1	$117.9	$298.1
2 TOOLING						
a DIRECT LABOR HOURS	1.9	3.1	0.9	3.1	2.8	6.2
b DIRECT LABOR DOLLARS	$ 5.7	$ 9.3	$ 3.2	$11.3	$ 8.9	$ 20.6
c OVERHEAD	15.6	26.6	6.7	25.5	22.3	52.1
d MATERIALS AND PURCHASED TOOLS	43.0	95.1	9.5	24.8	52.5	119.9
e OTHER DIRECT CHARGES	4.9	15.0	2.4	8.3	7.3	23.3
f TOTAL	$69.2	$146.0	$21.8	$69.9	$91.0	$215.9
3 QUALITY CONTROL						
a DIRECT LABOR HOURS	5.4	7.8	6.0	8.7	11.4	16.5
b DIRECT LABOR DOLLARS	$15.6	$ 23.4	$19.2	$29.6	$34.8	$ 53.0
c OVERHEAD	23.9	36.1	35.2	60.9	59.1	97.0
d OTHER DIRECT CHARGES	1.2	2.7	4.3	8.2	5.5	10.9
e TOTAL	$40.7	$62.2	$58.7	$98.7	$99.4	$160.9
4 MANUFACTURING						
a DIRECT LABOR HOURS	48.0	71.3	12.0	17.3	60.0	88.7
b DIRECT LABOR DOLLARS	$141.0	$ 214.0	$ 19.2	$ 54.7	$ 160.2	$ 268.7
c OVERHEAD	228.6	355.4	38.0	111.1	266.6	466.5
d MATERIALS AND PURCHASED PARTS	63.4	74.7	53.0	85.5	116.4	160.2
e OTHER DIRECT CHARGES	2.2	3.1	15.0	29.5	17.2	32.6
f TOTAL	$435.2	$647.2	$125.2	$280.8	$560.4	$928.0
5 PURCHASED EQUIPMENT	24.0	56.7			24.0	56.7
6 MATERIAL OVERHEAD	1.9	3.6	2.4	15.3	4.3	18.9
7 SUBCONTRACT (Non Airframe only)						
8 OTHER ITEMS NOT SHOWN ELSEWHERE	7.8	12.9	4.3	14.2	12.1	27.1
9 TOTAL COST (Less G&A)	$673.1	$1135.6	$236.0	$570.0	$909.1	$1705.6
10 G&A	-	-	13.8	28.5	13.8	28.5
11 FEE OR PROFIT			23.7	61.5	23.7	61.5
12 TOTAL	$673.1	$1135.6	$273.5	$660.0	$946.6	$1795.6

REMARKS

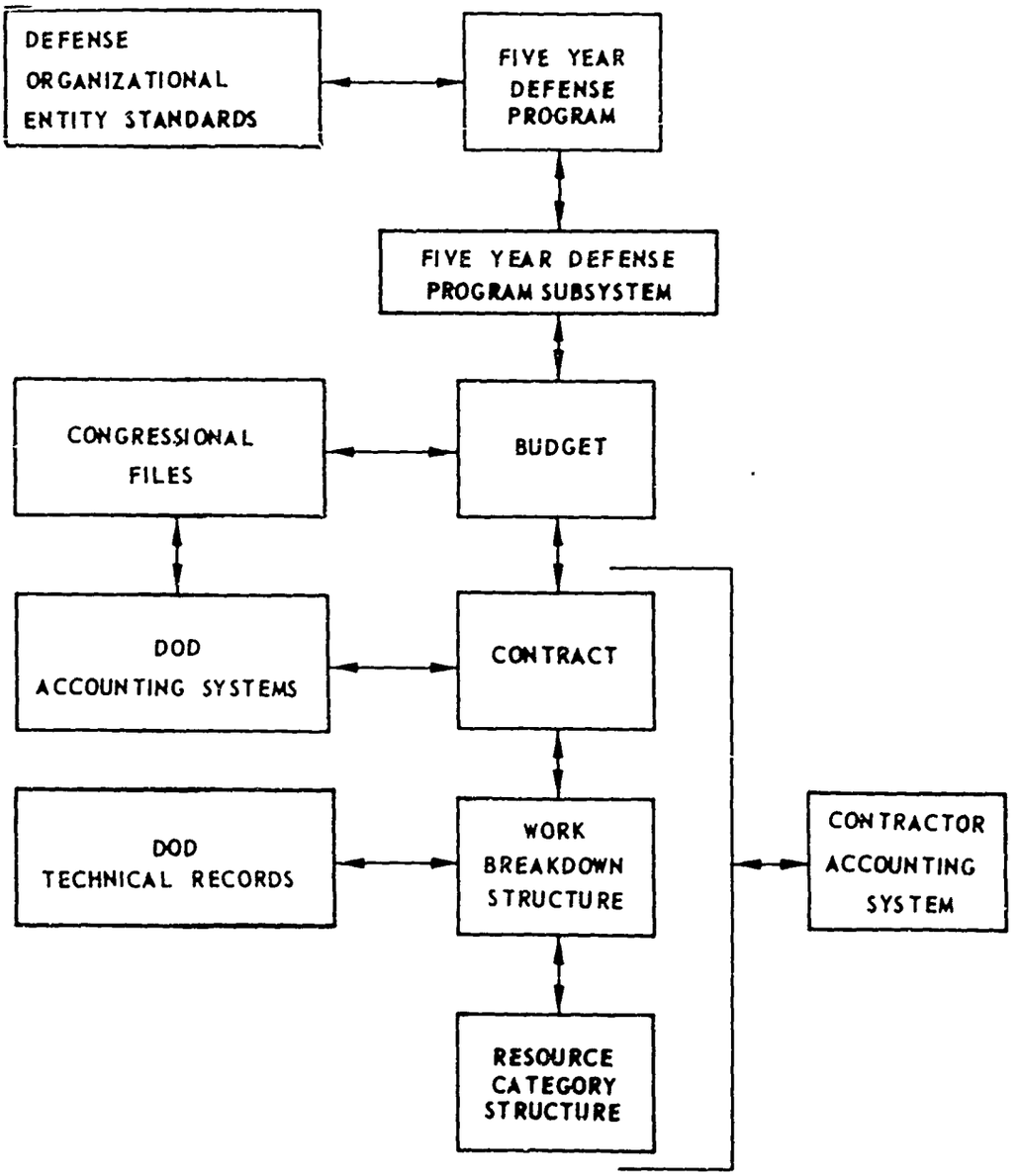
NAME OF PERSON TO BE CONTACTED	SIGNATURE	DATE

DD FORM 1 MAY 64 1558-1

(SECURITY CLASSIFICATION)

PAGE 1 OF 2

EXHIBIT II-16
MAJOR CODING STRUCTURE INTERFACES



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Chapter III

PROCEDURE FOR COST ANALYSIS

This handbook draws a clear distinction between the processes of cost analysis and cost estimating.

The process of cost analysis is the review, evaluation, and reduction of cost information presented in any cost document. Cost estimating is the use of cost information to approximate a cost to be incurred. In this context, the development of Cost Estimating Relationships (CERs) is a cost analysis task while the use of CERs to approximate or predict a cost is a cost estimating task. Thus, the difference between a cost analyst and a cost estimator is indicated by a comparison of their responsibilities:

- The cost analyst is responsible for:
  - Obtaining raw cost information from any source, such as contract cost reports, cost proposals, cost estimates specifications, schedule reports, test reports, etc.
  - Reviewing and evaluating the cost information.
  - Reducing cost data into usable aggregates.
  - Establishing,documenting and maintaining the cost data base.
  - Constructing and documenting cost estimating relationships.
- The cost estimator is responsible for:
  - Determining the content of the CERs as a record of history to ascertain their applicability for projection of that history to the specific estimating task at hand.
  - Assembling the set of CERs to be used in the cost estimate.
  - Supplementing the CERs with projections, expert opinions, etc., which will make them reflect the products and time frame set forth in the cost task.
  - Preparing and documenting the technical cost estimate.

- Providing support in compilation of the conditioned estimate.

A cost task may include both the cost analysis and cost estimating processes; thus, a clear distinction cannot be established for the positions of cost analyst and cost estimator. The current positional title, Cost Analyst, identifies a person skilled in both processes; however, this handbook will utilize the two titles, Cost Analyst and Cost Estimator, to signify association with the process.

While it is necessary to possess good "materials" (data, techniques, and procedures) for the production of a sound cost "product," the personnel involved in cost work must also possess a clear understanding of:

- The stated and implied purposes of the estimate and peripheral ramifications.
- The organizational and decision making environment in which the estimate is to be used.
- The technical characteristics of the item(s), its (their) history and the history of related items.
- The contracting environment in which the items have existed and are expected to exist in the time frame of the estimate.
- The capabilities and limitations of the cost estimating data, techniques, and procedures which are available.

This level of comprehension of the cost material is the mark of a good cost analyst/estimator.

This chapter discusses the process of cost analysis and the closely allied subject of acquisition of cost information. The process of cost estimating is introduced to the extent necessary for a discussion of CER construction.

III-1 COST INFORMATION DEFINITION

Cost information can be defined broadly as any intelligence which affects the magnitude of an expenditure of resources or the credibility of a source document containing such intelligence. Cost information can be separated into four categories--three quantitative and one qualitative. In that order the categories are as follows:

- Product Characteristics - This category includes the complete description of the item. It can generally be broken down into four groups:
  - Physical Characteristics - Typical of this group are weight, volume, materials, a description of component parts, etc. The Project (or Contract) Work Breakdown Structure often identifies the relationship among physical characteristics.
  - Technical Characteristics - Typical of this group are descriptions of the state-of-the-art, manufacturing tolerance and conditions, etc.
  - Performance Characteristics - Typical of this group are speeds, range, accuracies, power input and output, etc., Exhibit III-1 presents typical performance characteristics for a radar system.
  - Mission Characteristics - Typical of this group are the peacetime operational and combat employment concepts, readiness states, etc.

- Schedule - This category includes the quantity of items and the production schedule. In analysis and estimates conducted in the Army Materiel Command the following data at or above the third level of the Work Breakdown Structure WBS (Ref. III-1) will be sufficient:

  Production Release Date
  Delivery Dates
  Production Line Position
  Lot Quantities

- Resource Expenditure - This category includes the economic or resource inputs such as labor, materials, and capital investment to develop, test, produce and/or operate the item. This data is normally quoted in terms of dollars or manhours.

- Cost Document Status - This category includes narrative statements of the conditions under which the cost document was prepared and the degree of fiscal responsibility which was implied with the acceptance of the document. For example, the execution of a cost plus fixed fee contract by a contractor does not carry the same level of fiscal responsibility as execution of a firm fixed price contract, nor does an estimate made in a special

EXHIBIT III-1

TYPICAL PERFORMANCE CHARACTERISTICS

RADAR SYSTEM

CHARACTERISTICS	UNITS
1. Number of Channels	Number
2. Carrier Frequency (Primary)	Hertz
3. Band Width	Δ Hertz
4. Range	Miles
5. Input Power	Kilowatts
6. Output Power	Kilowatts
7. Range Error	Yards
8. Bearing Accuracy	Degrees
9. Elevation Error	Degrees
10. Pulse Repetition Frequency	Pulses per Second
11. Reliability	Percent
12. Detection Threshold	Equivalent Target Area at__yds
13. Antenna Gain	Decibels
14. Antenna or Tracking Speed	Degrees/Second
15. System Gain	Decibels
16. Display Method	Specific Notations
17. Resolution	Equivalent Yards
18. Field of View	Degrees

study carry the same fiscal responsibility as a proposal for a contract, etc. Included are narrative statements addressing such subjects as these:

- The purpose for which the preparer intended the cost document.
- The environment in which the cost document was prepared.
- The stated and implied ground rules for preparation.
- The developmental status of the items being costed.
- The characteristics of the data base used in preparation.
- The status of the product characteristics at time of preparation.
- The time allowed for preparation of the cost document.

III-2 ACQUISITION OF COST INFORMATION

This section addresses the acquisition of cost information and discusses the major credibility characteristics of selected sources. Exhibit III-2 lists the major types of cost information documents and their normal originator. The initial point of contact for obtaining these information documents is the contract technical officer. The Army Publications System, Defense Documentation Center, Defense Logistics Studies Information Exchange, etc., are secondary sources.

The itemization under each information category generally reflects:

- Availability to the cost analyst. (The first being more generally available).
- Availability in the life of a project. (The first being the earliest in the project).
- Level of detail and comprehensiveness. (The first being the least detailed).

EXHIBIT III-2

COST INFORMATION DOCUMENTS

	ORIGINATOR	
	Industry	Government
PRODUCT CHARACTERISTICS		
Estimates		
Operational Requirements		X
Technical Development Plan		X
Procurement Request		X
Performance Specifications	X	X
Detailed Specifications	X	X
Actuals		
Test Results	X	X
Technical Manuals	X	X
SCHEDULE		
Estimates		
Operational Requirements		X
Technical Development Plan		X
Procurement Request		X
Bid	X	
Project Managers Reports	X	X
Actuals		
Acceptance Document		X
Contractor Reports	X	
Project Managers Reports	X	X
RESOURCE EXPENDITURE		
Estimates		
Special Study	X	X
Proposal		
Administrative-Decision Making		X
Budgeting		X
Procurement Request		X
Bid to Accomplish	X	
Audit Reports		X
Actuals		
Audit Reports		X
Project Managers Reports	X	
Cost Information Reports	X	
Accounting Reports	X	

The credibility of the information tends to flow in the reverse-- the historical records being the most accurate recording of the accomplishments. This list forms a general order of precedence in selection of data; however, such an order of precedence must be tempered by the knowledge of specific capabilities of each source. For example, one command may have developed its cost analysis/cost estimating capability to the point where its special studies are more credible than another command's budget request. Or, one contractor's cost estimate may be much more realistic than another's. These special qualities are dynamic and can be determined only through continuous monitoring.

III-2-a. Product Characteristics

The principal sources of product characteristics are the government project, technical, and procurement files. From the project and technical files one may obtain information regarding the desires of the government. The procurement files can provide the specifications included in the Procurement Request (Request for Proposal (RFP), Invitation for Bid (IFB), etc.).

Performance and detailed specifications may be produced by either the government or industry. In projects coming within the scope of DoD Directive 3200.9 "Initiation of Engineering and Operational Systems Development", (Ref. III-2) the performance specifications are prepared by the participating contract definition contractors and the detailed specifications are prepared by the contractor receiving the development and production contract. The most accurate product characteristics throughout this entire chain are those which will be demonstrated and documented in the test program.

The use of product characteristics (other than weight) in cost analysis and cost estimating has been essentially a subjective evaluation. However, recently some emphasis has been placed upon a more formalized and direct relationship between product characteristics, particularly in construction of CERs. The principal difficulties with their use in cost analysis and cost estimating are these:

- The procurement files are contract oriented or, at best, are a reflection of the technical files which tend to be oriented toward products of specific technologies. Neither of these sources provides a clear measure of product characteristics at the higher work breakdown structure levels where most cost tasks are oriented.

- Product characteristics tend to change as the product progresses through the development/production cycle.

Exhibit III-3 presents a typical progression. This progression and its effect upon cost normally have not been clearly documented or analyzed.

III-2-b Schedule

The principal sources of schedule data are the project and procurement files, which should include summaries from the Materiel Inspection and Receiving Report (MIRR), DD Form 250. Information from the contractor should be required only in cases where:

- Analyses of incurred costs are being conducted while work is in process.
- There is concurrent production for other customers.
- Detailed funding studies are being conducted.

The principal difficulties with schedule data are in the determination of production line position when an item is being produced for more than one customer and in determining the stage of completion of any one item on the production line, since the percent of materials in place might be quite different from the percent of labor hours used in production at any point in time.

III-2-c Resource Expenditure

The preference for Resource Expenditure Information by source was presented in Exhibit III-2 and a preference was cited for contractor generated data. This section will concentrate upon the contractor supplied data, since that is the primary base for all procurement Resource Expenditure information.

In addition to special studies there are three types of resource expenditure documents, Proposals, Cost Reports and Change Price Proposals generated by the contractor. Exhibit III-4 places these in the context in which they are generated and indicates the participating organizations and the actions which lend credibility to the documents.

The first two columns of this exhibit, Procurement Organization and Contractor, are self explanatory. The organizations identified with the last column, Contract Management, are less well known. The two of major interest are:

EXHIBIT III-3
TYPICAL PROGRESSION OF PRODUCT CHARACTERISTICS

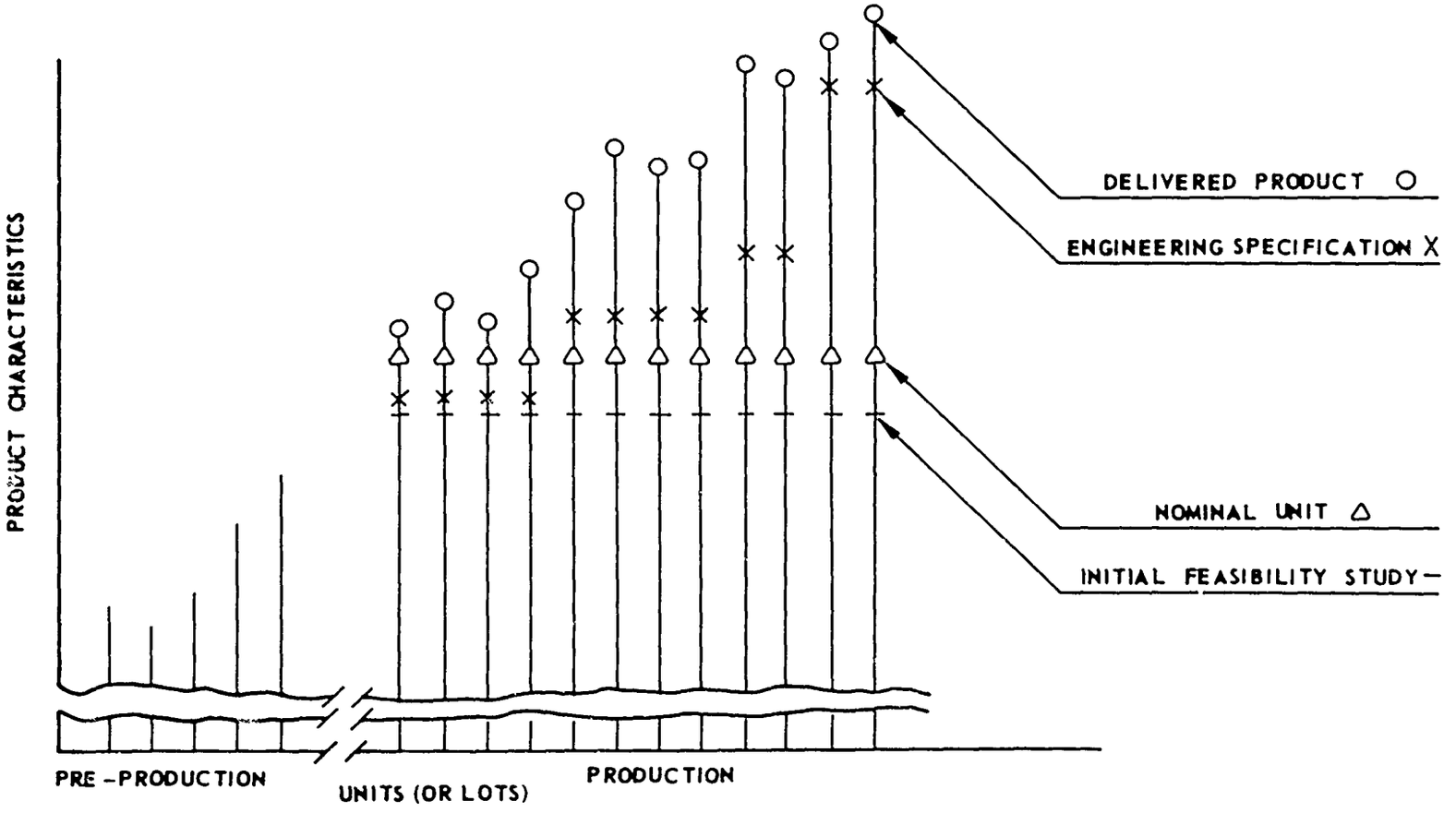
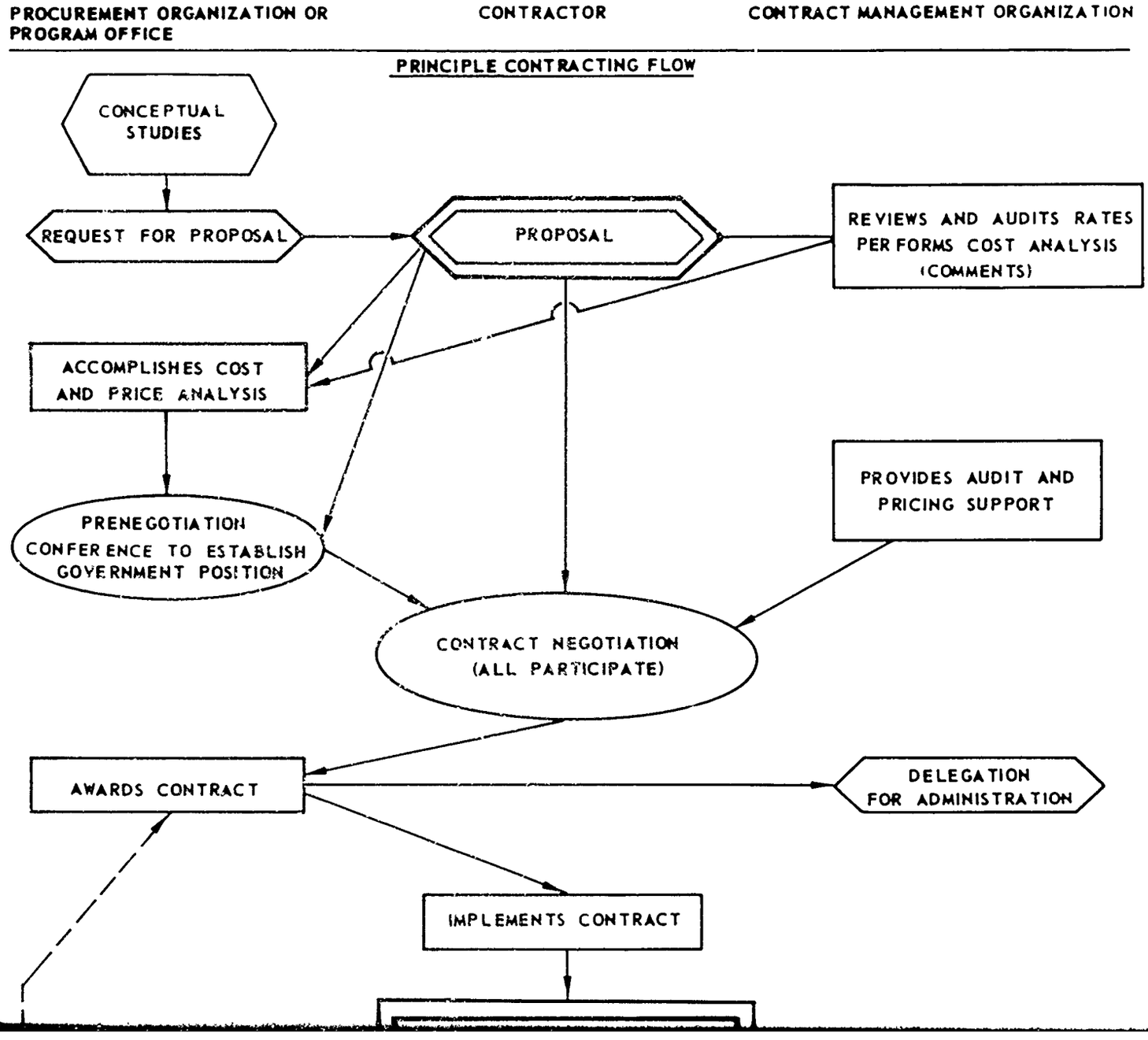
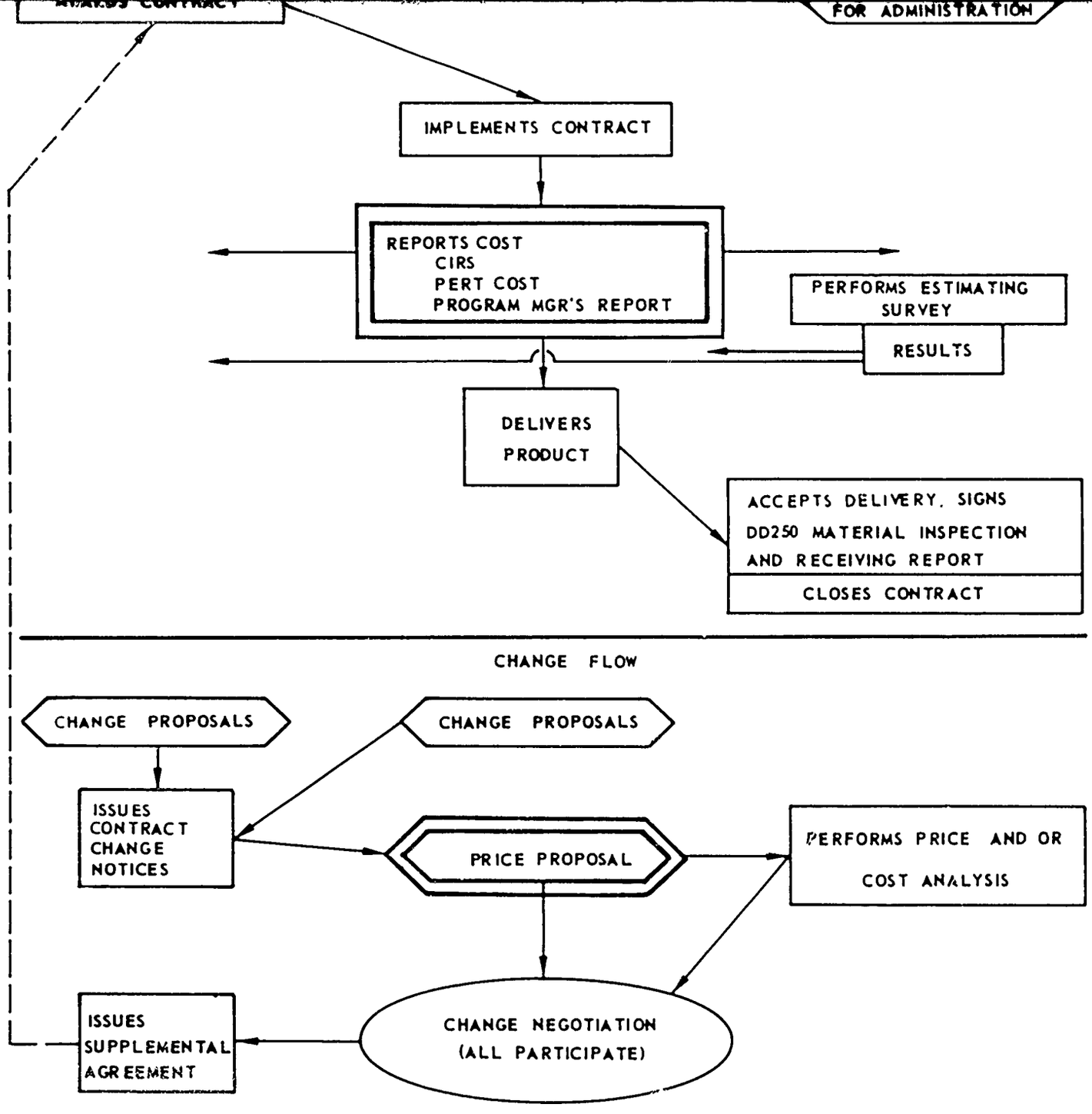


EXHIBIT III–4

CONTRACT FLOW CHART




FOR ADMINISTRATION
IMPLEMENTS CONTRACT
REPORTS COST
CIRS
PERT COST
PROGRAM MGR'S REPORT
PERFORMS ESTIMATING SURVEY
RESULTS
DELIVERS PRODUCT
ACCEPTS DELIVERY, SIGNS DD250 MATERIAL INSPECTION AND RECEIVING REPORT
CLOSES CONTRACT
CHANGE FLOW
CHANGE PROPOSALS
CHANGE PROPOSALS
ISSUES CONTRACT CHANGE NOTICES
PRICE PROPOSAL
PERFORMS PRICE AND OR COST ANALYSIS
ISSUES SUPPLEMENTAL AGREEMENT
CHANGE NEGOTIATION (ALL PARTICIPATE)

- Administration Service. With major contractors, this is normally one of the military departments. With others, it is normally the Defense Contract Administration Service (DCAS). The administration service has the responsibility of assuring that the terms of the contract are met--including schedule, technical and quality.

- Audit Agency - Under current DoD organization this is the Defense Contract Audit Agency (DCAA), the only DoD organization which has direct access to the contractor's accounting records.

Exhibit III-4 presents the typical flow of a competitive contract. The first contract oriented document is the Request for Proposal (RFP) or Invitation for Bid (IFB). This document includes a description of the anticipated procurement (technical and mission characteristics, quantity of items, delivery schedule, etc.) and the ground rules for bidding (due date and format of bid, type of contract anticipated, etc.). This document, together with the relationship and understanding which have been established between the buyer and the seller, sets the content of the contractor's proposal.

Based upon the requirements established in the RFP and his competitive position, the contractor prepares his technical, schedule and price proposal.

The price proposal in accordance with the Armed Services Procurement Regulation (Ref. III-3) includes, at a minimum, one of the DD633 series forms. Exhibit III-5 presents the most frequently used form in this series. The contractor may be required to prepare one of these forms for each major item in the contract or just one for the total contract. In addition to this form the contractor may provide (or be required to provide) data on estimating methods (possibly his estimating worksheets) and additional resource expenditure information, such as manhours, number of engineering drawings, machine hours, subcontract structure, etc.

The credibility attributed to contractor proposals, particularly for cost plus fee and cost plus fixed fee contracts, has not been high in the past. However, two recent occurrences have done much to initiate improvements in the accuracy of price proposals:

- Certificate of Current Cost and Pricing Data - In response to Public Law 87-654, 10 U.S.C. 2306, "Truth in Negotiations Act," the above certificate has been required in proposals. (Ref. III-4). This certificate has the weight of law and has been enforced by recent decisions of the Armed Services Board of Contract Appeals.

DEPARTMENT OF DEFENSE

CONTRACT PRICING PROPOSAL

Form Approved
Budget Bureau No. 22-R100

This form is for use when submission of cost or pricing data (see ASPR 3-807.3) is required

PAGE NO. | NO. OF PAGES

NAME OF OFFEROR | TYPE OF ORGANIZATION (Corporation, partnership, individual)

NUMBER AND STREET | CITY | COUNTY | STATE | ZIP CODE

TOTAL AMOUNT OF PROPOSAL
$

NAME AND ADDRESS (Number and street, city, county, State, and ZIP Code) OF PLANT WHERE MATERIAL WILL BE PRODUCED OR SERVICES PERFORMED

GOVERNMENT FISCAL YEAR ENDING

PROPOSED CONTRACT ESTIMATE

COST ELEMENTS	TOTAL COST	UNIT PRICE	REFERENCE
DIRECT MATERIAL: a. PURCHASED PARTS			
b. SUBCONTRACTED ITEMS			
c. RAW MATERIAL			
d. STANDARD COMMERCIAL ITEMS			
e. INTRADIVISIONAL TRANSFERS (at other than cost)			
f. MATERIAL OVERHEAD			
g. INTERDIVISIONAL TRANSFERS (at cost)			
DIRECT LABOR: h. DIRECT LABOR (man-hours and amount)			
i. ENGINEERING LABOR (man-hours and cost)			
j. DIRECTION (man-hours and amount)			
k. MANUFACTURING OVERHEAD			
l. OTHER COSTS			
m. SUBTOTALS			
n. GENERAL AND ADMINISTRATIVE EXPENSES			
o. ROYALTIES			
p. FEDERAL EXCISE TAX			
q. SUBTOTALS			
r. PROFIT OR FEE			
s. TOTAL PRICE (Amount)			

1. HAVE THE DEPARTMENT OF DEFENSE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OR THE ATOMIC ENERGY COMMISSION PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

YES NO IF YES, IDENTIFY

NAME AND ADDRESS OF REVIEWING OFFICE | TELEPHONE NUMBER

2. WILL IT BE REQUIRED THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

YES NO IF YES, IDENTIFY ON A SEPARATE PAGE

3. DOES THE AMOUNTS SHOWN ON THIS FORM INCLUDE (i) ANY CHARGE FOR PROPERTY WHICH DUPLICATES ANY CHARGE AGAINST AN EXISTING OR CURRENT GOVERNMENT CONTRACT OR SUBCONTRACT OR (ii) ANY RENTAL OR USE CHARGE ON GOVERNMENT PROPERTY?

YES NO IF YES, JUSTIFY ON SEPARATE PAGE

4. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

YES NO IF YES, IDENTIFY ; ADVANCE PAYMENTS ; PROGRESS PAYMENTS OR ; GUARANTEED LOANS

5. ARE YOU NOW BEING AWARDED ANY CONTRACTS OR SUBCONTRACTS FOR SIMILAR ITEMS WITHIN THE PAST THREE YEARS?

YES NO IF YES, SHOW CUSTOMER(S) AND CONTRACT NUMBERS BELOW OR ON A SEPARATE PAGE

6. DO THE AMOUNTS SHOWN ON THIS FORM INCLUDE ANY CHARGE FOR OVERTIME PREMIUMS OTHER THAN OVERTIME OF THE TYPES DESCRIBED IN ASPR 12-108.5

YES NO IF YES, EXPLAIN ON A SEPARATE PAGE

7. DOES THE COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN ASPR SECTION XV (see 3-807.3(c)(3))?

YES NO IF NO, EXPLAIN ON A SEPARATE PAGE

This proposal is submitted for use in connection with and in response to _____

_____ * and reflects our best estimates as of this date, in accordance with the Instructions to Offerors and the Footnotes which follow.

*DESCRIBE RFP, ETC.

TYPED NAME AND TITLE | SIGNATURE

NAME OF FIRM | DATE OF SUBMISSION

DD FORM 1 DEC 66 633 PREVIOUS EDITIONS ARE OBSOLETE

1 The purpose of this form is to provid format by which the offeror submits to th a summary of incurred and estimated cos *supporting information)* suitable for deta analysis. Prior to the award of a contra this proposal the offeror shall, under the stated in ASPR 3-807.3, be required to s Certificate of Current Cost or Pricing Data (s 3-807.3(e) and 3-807.4).

2 In addition to the specific informatio this form, the offeror is expected to ga cooperate in and submit with this form al data supporting schedules or substantia reasonably required for the conduct of an review and analysis in the light of the s of this procurement. For effective negoti essential that there be a clear understan

a The existing, verifiable data

b The judgmental factors applied t from known data to the estimate

c The contingencies used by the o proposed price

In short, the offeror's estimating process to be disclosed.

NOTE 1. Enter in this column those ne reasonable costs which in the judgment will properly be incurred in the efficien of the contract. When any of the costs i have already been incurred (e.g., on a t or change order) describe them on an at ing schedule. When "pre-production" o costs are significant or when specifical detail by the contracting officer, provide fication and explanation of same. Ident and transfers between your plants, divisi zations under a common control, which a other than the lower of cost to the organi or current market price.

NOTE 2. The use of this column is opt line item proposals, except where the co determines that a separate DD Form 633 selected line items.

NOTE 3. Attach separate pages as nec tify in this column the attachment in wh tion supporting the specific cost elemen No standard format is prescribed, howev pricing data must be accurate, complete and the judgment factors used in project data to the estimates must be stated in s to enable the Contracting Officer to eva posal. For example, provide the basis the bill of materials such as by vendor q shop estimates, or invoice prices; the n overhead rates which depart significantl rates (*reduced volume, planned major* etc.) or justification for an increase in (*anticipated wage and salary increases*, tify and explain any contingencies whic in the proposed price, such as anticipat rejects and defective work, anticipated ing redesign and retesting, or anticipate difficulties in designing high risk comp

NOTE 4. Provide a list of principal ite category of material indicating known o source, quantity, unit price, competitor basis of establishing source and reason

NOTE 5. Include material for the propo than material described in the other foo cost element entitled "Direct Material."

NOTE 6. Include parts, components, a services to be produced or performed by in accordance with your designs, specif directions and applicable only to the pr

A

INSTRUCTIONS TO OFFERORS

f this form is to provide a standard he offeror submits to the Government urred and estimated costs *(and attached* *ations)* suitable for detailed review and the award of a contract resulting from offeror shall under the conditions 807 1 be required to submit a Certi Cost or Pricing Data (see *ASPR* 907 4)

the specific information required by eror is expected, in good faith, to in submit with this form any additional schedules or substantiation which are ed for the conduct of an appropriate sis in the light of the specific facts at For effective negotiations it is re be a clear understanding of

ing verifiable data

nental factors applied in projecting n data to the estimate and

agencies used by the offeror in his price

ror's estimating process itself needs

3 When attachment of supporting cost or pricing data to this form is impracticable, the data will be described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request

4 The format and the prescribed cost breakdown are not intended as rigid requirements. With the approval of the contracting officer the data may be presented in another form if required for a more effective and efficient presentation of cost or pricing data

5 By submission of this proposal the offeror grants to the Contracting Officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

---

n this column those necessary and which in the judgment of the offeror incurred in the efficient performance When any of the costs in this column n incurred *(e g on a letter contract* describe them on an attached support ten "pre-production" or "startup" ant or when specifically requested in tracting officer, provide a full identi anation of same. Identify all sales ween your plants, divisions, or organi ommon control, which are included at ver of cost to the original transferror price

e of this column is optional for multiple ls, except where the contracting officer separate DD Form 633 is required for ns

separate pages as necessary and iden n the attachment in which the informa specific cost element may be found. at is prescribed, however, the cost or be accurate, complete and current. factors used in projecting from the ates must be stated in sufficient detail ntracting Officer to evaluate the pro ple, provide the basis used for pricing als such as by vendor quotations, or invoice prices the reason for use of hich depart significantly from experienced *lume a planned major rearrangement* tion for an increase in labor rates *and salary increases* etc) Iden any contingencies which are included rice, such as anticipated costs of tive work, anticipated costs of engineer retesting, or anticipated technical signing high risk components

e a list of principal items within each ial indicating known or anticipated unit price competition obtained, and hing source and reasonableness of cost

material for the proposed contract other cribed in the other footnotes under the tled "Direct Material."

parts components, assemblies, and oduced or performed by other than you th your designs, specifications, or plicable only to the prime contract

NOTE 7 Include raw and processed material for the proposed contract in a form or state which requires further processing

NOTE 8. Include standard commercial items normally fabricated in whole or in part by you which are generally stocked in inventory. Provide explanation for inclusion at other than the lower of cost or current market price.

NOTE 9. Include all materials sold or transferred between your plants, divisions or organizations under a common control at other than cost to the original transferror and provide explanation of pricing method used

NOTE 10. Provide the method of computation and application of your overhead expense, including cost breakdown, and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates.

NOTE 11. Include separate breakdown of costs.

NOTE 12 Provide a separate breakdown of labor by job category and furnish basis for cost estimates.

NOTE 13 Include all other estimated costs *(e g , special tooling, facilities, special test equipment, special plant rearrangement, preservation packaging and packing, spoilage and rework, and warranty)* which are not otherwise included Identify separately each category of cost and provide supporting details If the proposal is based on a F O B destination price, indicate separately all outbound transportation costs included in total amount

NOTE 14 If the total cost entered here is in excess of $250, provide on a separate page *(or on DD Form 783, Royalty Report)* the following information on each separate item of royalty or license fee name and address of licensor, date of license agreement, patent numbers, patent application serial numbers, or other basis on which the royalty is payable, brief description, including any part or model numbers of each contract item or component on which the royalty is payable, percentage or dollar rate of royalty per unit, unit price of contract item, number of units, and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided

NOTE 15 Selling price must include any applicable Federal excise tax on finished articles.

EXHIBIT III-5

CONTRACT PRICING PROPOSAL DD-633

B

- Reviews of Contractor's Estimating System - This program of the contract management organization, with the Defense Contract Audit Agency taking the lead, provides a qualitative evaluation of the contractor's estimating system and recommendations for improvements. See Defense Procurement Circular Number 50 (Ref. III-5). Copies of the survey results are made available to each purchasing and contract administration office having substantial business with the contractor.

Thus, there is a strong impetus for improved estimates in the contractor's proposal.

Upon receipt of the contractor's proposal, the Contract Management Organization may be requested to audit the proposal and conduct a procurement type price and/or cost analysis. The Procurement Organization may also conduct such a price and/or cost analysis.

The government's initial negotiating position is established based on the information from the contractor, from Contract Management Organization and from in-house comments.

On this basis the contract is negotiated with the potential contractor (or contractors). This negotiation establishes the contract objectives and the price for which the contractor will agree to accomplish the current objectives. In the above proposal negotiating iteration, many cost positions and estimates are taken, and many estimates are made which culminate in a contract price. Some of these estimates may be in detail; others may be gross in nature. These positions and estimates form a valuable source of cost information; however, the cost analyst must have a thorough understanding of the contracting cycle to utilize this type of data in cost analysis.

The price determined by the negotiating process can be assumed to be relatively accurate; however, supplemental agreements (reflecting changes in technical scope of the program and underestimates in the case of cost plus fixed fee and incentive type contracts) have tended to increase the contract price. It has been difficult, if not impossible, to determine the amount of the increase which is due to technical changes and that which is a correction of previous underestimates. The general rule of thumb has been to use the fee negotiation as the guideline--if an increase in fee is allowed it is a scope-of-work, or technical change; if no additional fee is allowed, it is an overrun. A thorough examination of contract changes will help the analyst in evaluating potential cost impact of technical changes.

During the execution of the terms of the contract, cost reports such as Cost Information Reports (CIR), PERT*/Cost, Project Managers Reports, Contract Funds Status Reports, etc., may be required. These data are not collected on a consistent basis for all contracts or contractors. The specific definition and, therefore, the content of the data are subject to negotiations. For example, data reported in a CIR is, by official definition, on an applied basis; that is, it is a direct reflection of the labor and material applied to the program. However, it is possible that agreements can be reached whereby some of this data is placed on a disbursement basis; that is, it is a direct reflection of the contractor's payments. In the materials and subcontract area, this can create a considerable difference in time phasing of costs.

Project Managers' reports, when these are included in a contract, are normally designed for the specific projects. These reports can be expected to have little consistency from project to project. PERT/Cost is much like the project managers' reports. The Contract Funds Status Report is essentially a report of current and anticipated billings; therefore, it reflects the peculiarities inherent in the progress payment of agreements written into the contracts.

The above statements should not be interpreted as negating the use of cost reports in cost analysis; however, the pitfalls are many, and considerable knowledge is required to avoid them.

III-3 VALIDATION PROCEDURE

The procedure for establishing the credibility of cost information is an iterative process. The initial steps are as follows:

- Evaluation of source documentation
- Evaluation of technique
- Comparison with prior information

The first two of these steps are best accomplished by study of the working reports which usually detail the elements of cost in the cost document, if such reports are available. Working reports tend to reveal more data since they are considered to be on a more technical basis. The latter step provides an order of magnitude check.

- Evaluation of source documentation determines whether the best and/or most current data was utilized in preparation of the estimate and if the data sources were compatible. This step in validation presumes the cost analyst is familiar with the cost documents.
- Evaluation of the techniques ensures that the cost document does not mix apples and oranges. This is of concern particularly

where the three categories of cost information have been combined in a cost analysis or cost estimate. For example, the evaluation should ensure that the cost product characteristics and schedule data relate to a single defined production program. It may not be appropriate to use estimated costs with an actual schedule or vice versa, particularly where the actual schedule deviates markedly from the estimated schedule.

- Comparison with Prior Estimates - This step is a gross comparison with previous estimated or actual figures to identify significant deviations of the derived costs from recognized history.

Cost Estimate Tracking, such as that described in the Air Force Systems Command's "Estimate Tracking System" (Ref. III-6) provides a disciplined approach to validation by maintaining a complete record of past cost estimates. This subject is treated in Section V-6.

The objective of these validation steps is to establish to what extent further analysis of the cost document is warranted. Further validation may be accomplished during the detailed cost analysis where the data are reduced to less complex forms and comparisons between estimates for similar or related systems are made.

Validation of contractor cost reports is a more difficult task, since a careful correlation between schedule and reported costs, including estimates of work in process, must be accomplished. In the CIR reports the contractor is required to derive "unit costs" and "learning curves" (based upon the aggregated state of completion of all elements currently in production). This requirement reduces the cost analysis work load; however, validation procedures should require an independent determination of these data to provide a cross check on the reported numbers.

This validation procedure should be addressed to all cost information documents with particular emphasis upon the changes which occur over time, such as these:

- Program changes
- Development objective changes
- Requirements changes
- Force changes
- Modifications (product improvements)
- Contract changes
- Budgetary changes

III-3, Validation Procedure

Chapter V presents a detailed treatment of validation procedures from which analogues can be drawn for validation of cost analyses.

III-4 CONSOLIDATING AND STRUCTURING INFORMATION

Cost information is available from diverse sources. This is true of cost, product characteristics, and to a lesser degree, schedule.

Cost information from contractors is essentially a mirroring of the contractors' production processes, internal management, and the accounting conventions established by the contractor and generally agreed to by government auditors from such organizations as the Internal Revenue Service (IRS) and the Defense Contract Audit Agency (DCAA). Since contractor provided costs are the principal basis for all government procurement costs, a means for restructuring data to a common base is necessary.

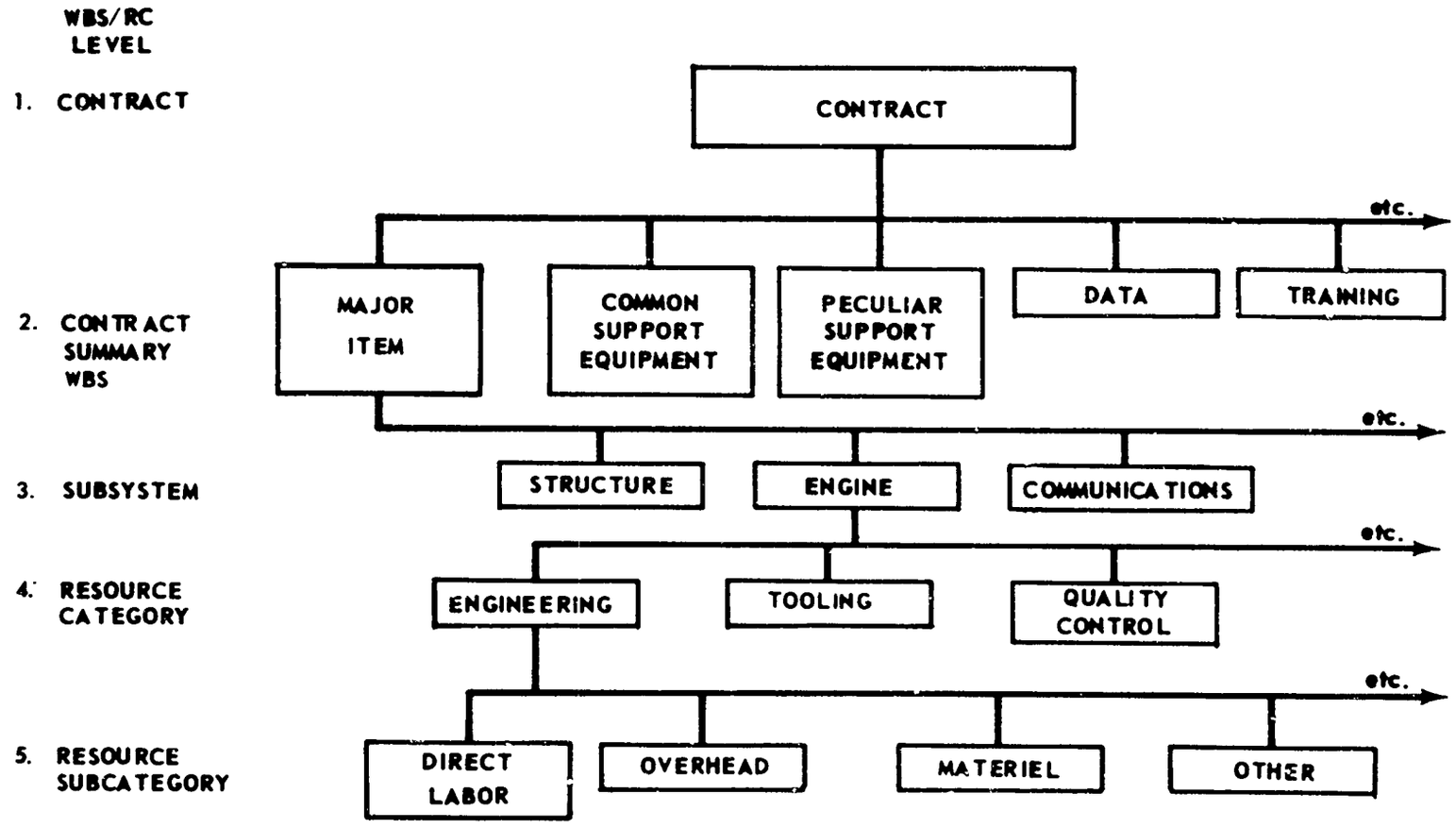
The first step is to develop a well defined work breakdown structure such as those developed in the proposed DoD Directive "Work Breakdown Structure for Defense Materiel Items" (Ref. III-1). This WBS effort is important for establishing a consistent, systematic framework which is common to all disciplines associated with the materiel item (or system) and with analogous items (or systems).

Similarly, the resource category structure must be defined clearly. The CIR system, as presented in Reference III-7, provides a series of definitions of functional cost categories which can serve as a base point for creating standard resource categories to be used in the data base. A similar structure, although not as well defined, is available at the total proposal level in the Contract Pricing Proposal (DD Form 633) or others of this series which must accompany each proposal (Ref. III-3). In establishing such a resource structure it must be realized that various levels of data will be available and not always the same level on similar contracts. For example, Exhibit III-6 presents an extract of the top five levels of a Typical Contract WBS for cost reporting. The lower two levels of this structure are the Resource Category Structure. As discussed in section one of this chapter, cost documents originating from contractor sources may address any of these levels. The initial analysis task is to determine the level at which the analysis will be accomplished.

A second problem which exists is the separation of variable and non-variable costs. If this is readily identified in the cost document, recognition should be taken in the restructuring. If it is not identified, one of the tasks of cost analysis will be to separate the variable and non-variable costs analytically.

EXHIBIT III-6

EXTRACT OF TYPICAL CONTRACT WORK BREAKDOWN/RESOURCE CATEGORY STRUCTURE



III-5 COST ANALYSIS

The next steps in the cost analysis process are to:

- Reduce the resource expenditure data to a reference unit (the equivalent cost of unit one). It should be noted that this reference unit cost does not necessarily equal the cost of the first unit produced. It merely serves as a reference point for cost analysis purposes.

- Validate the derived reference unit.

The first step establishes the cost/quantity relationship. This is normally accomplished by using the Modified Wright Learning Curve,* which expresses the unit production cost as a log linear function of production quantity. Exhibit III-7 presents a typical derivation of a learning curve.

To use the learning curve theory in cost analysis one should possess at least 3 good data points beyond the first production unit. With any less than this, the analyst must rely on expert opinion regarding industry's experience with learning curve slopes. Generally, the first lot data must be handled with care since it is difficult to isolate all the non-variable cost using accounting data or cost estimates.

Typical conclusions which could be drawn from Exhibit III-7 are:

- The cost of the reference unit is $2,300.

- Learning curve slope is 87%, i.e., the unit cost reduces 13% with each doubling of the production quantity.

- There may be approximately $54,000 non-variable cost in the first production lot. This conclusion could be drawn from the relatively good fit of the last four units with a variation of roughly $2,700 between the average cost of the first unit and the cost of the algebraic midpoint.

Anomalies similar to the above first lot data often appear in the use of progress curves. These anomalies call attention to vague or undocumented factors such as a work distribution or a model change. A more extensive treatment of Learning Curves is presented in Appendix A.

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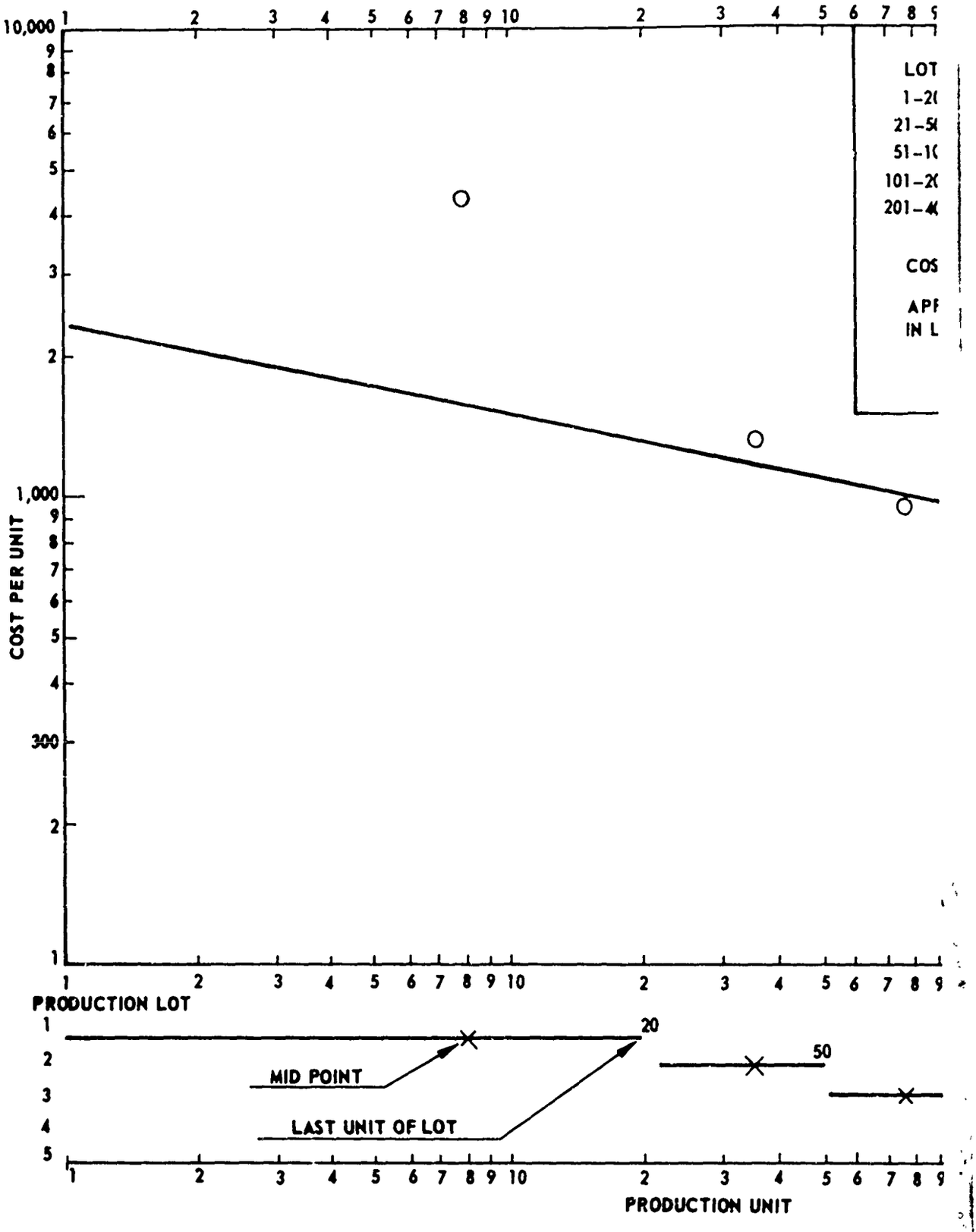
* Note: Also referred to as a progress curve and experience curve. See Alpha and Omega and the Experience Curve (Ref. III-7).


10,000
1,000
300
COST PER UNIT
PRODUCTION LOT
PRODUCTION UNIT
MID POINT
LAST UNIT OF LOT
20
50
LOT
1-2(
21-5(
51-1(
101-2(
201-4(
COS
APF
IN L

A

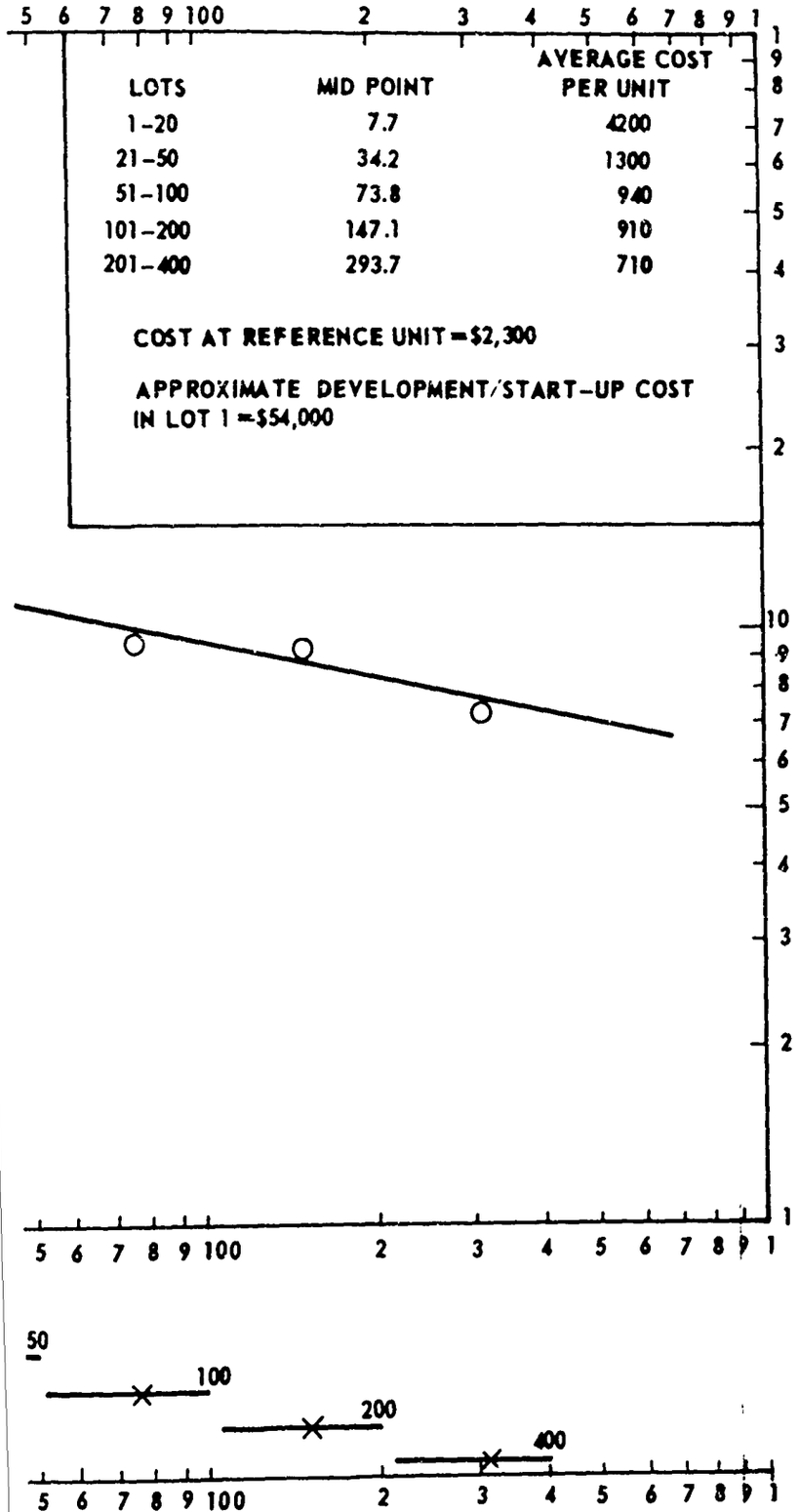


EXHIBIT III-7

TYPICAL USE OF LEARNING CURVE

B

The second step, validation of the reference unit costs, can take three forms:

- Reduction of the reference unit data to index or factor form, such as cost per pound, and comparing these data to those of similar or even related items. For example, a heavy tank could be compared with other heavy tanks, light tanks, armored tracked vehicles, or even boats, to determine the the direction and reasonableness of the deviation.

- Computation of cost factor ratios, such as engineering cost per manufacturing dollar, manufacturing cost per material dollar, etc., and comparison with similar or related items.

- Comparison of reference unit costs with estimates of the item costs derived from CERs based on prior items.

This last action is the final point in the validation of a given set of data. At this point the cost analyst should be able to identify clearly the degree of credibility which the set of data possesses.

III-6 COST ESTIMATING RELATIONSHIPS

Cost estimating has been defined in this handbook as the process of approximating the cost to be incurred. This judgment of the cost to be incurred may be arrived at formally or informally. In some cases, experience provides a clear guide, particularly in estimation of standard items such as pipes and valves. Slightly more sophisticated are the estimates of rather standard items in non-standard sizes, such as oversized pipes or off-sized valves or a state-of-the-art increase in the size of an engine. A more sophisticated problem is that of estimating cost of new items such as a rifle, tank, or aircraft.

All formal estimating methods use some form of Cost Estimating Relationships (CERs), which are defined as:

> " functional expressions which state that the cost of something may be estimated on the basis of a certain variable or set of variables. The relationship is derived by analyzing historical data on different systems to obtain a functional relationship between several system characteristics. The variable to be estimated will be called the dependent variable, and the variables to which the dependent variable is related by the CER will be called the independent variables. A CER in which

the cost is directly proportional to a single independent variable is called a cost factor." (Ref.III-9)

Whether the cost analyst creates a simple or highly sophisticated CER depends upon such factors as the tools, techniques, and data base available, as well as the level of sophistication of the analyst.

The CER, as presented here, is concerned only with determination of the magnitude of resource expenditure input required to produce the reference unit. Derivation of CERs then is concerned with selection of the independent variables to be used in the relationship. These independent variables are selected from the product characteristics described in Section III-1 as being of four classes:

- Physical
- Technical
- Performance
- Mission

Selection of the specific characteristics is conditioned by:

- The objective of the study.
- The developmental status of the item.
- The availability of compatible data.
- The number of data points available.

The techniques for derivation of CERs are:

- Statistical
- Simple Analogue
- Engineering
- Expert Opinion

These are listed in general order of preference; however, the selection is conditioned most often by what is possible rather than what is preferred.

III-6-a Statistical

The statistical method for derivation of CERs is the most sophisticated of the three. This method may take five forms;

- Average - the arithmetic mean.
- Simple Linear - a first order equation with two variables, the dependent variable being cost and the independent variable being a product characteristic.
- Simple Non-Linear - an equation of second or higher order or of any other form such as exponential, with two variables, the dependent variable being a product characteristic.
- Multiple Linear - a first order equation with more than one independent variable, each of these independent variables being a product characteristic.
- Multiple Non-linear - an equation of second or higher order or of any other form such as exponential, with more than two variables, the dependent variable being cost and the independent variables being product characteristics.

Exhibit III-8 is a graphic presentation of a simple linear equation where two physical characteristics have been combined into one prior to construction of the CER.* In this presentation the dependent variable is a factor (cost per pound) which must be extended to derive total cost. The same equation written at the total level becomes the following multiple non-linear equation:

$$\text{Airframe Cost} = 120.211\ (W) + 24.011\ \left(\frac{W^2}{V}\right)$$

Where W = CIR Airframe Unit Weight

V = Airframe Volume

The use of statistical techniques for CERs has widened the scope of the normal field of statistics beyond that normally found in statistical texts. The data points are derived from a non-controlled universe (sometimes from a universe of three or four observations) and the objective of the CER is to extrapolate beyond the data base.

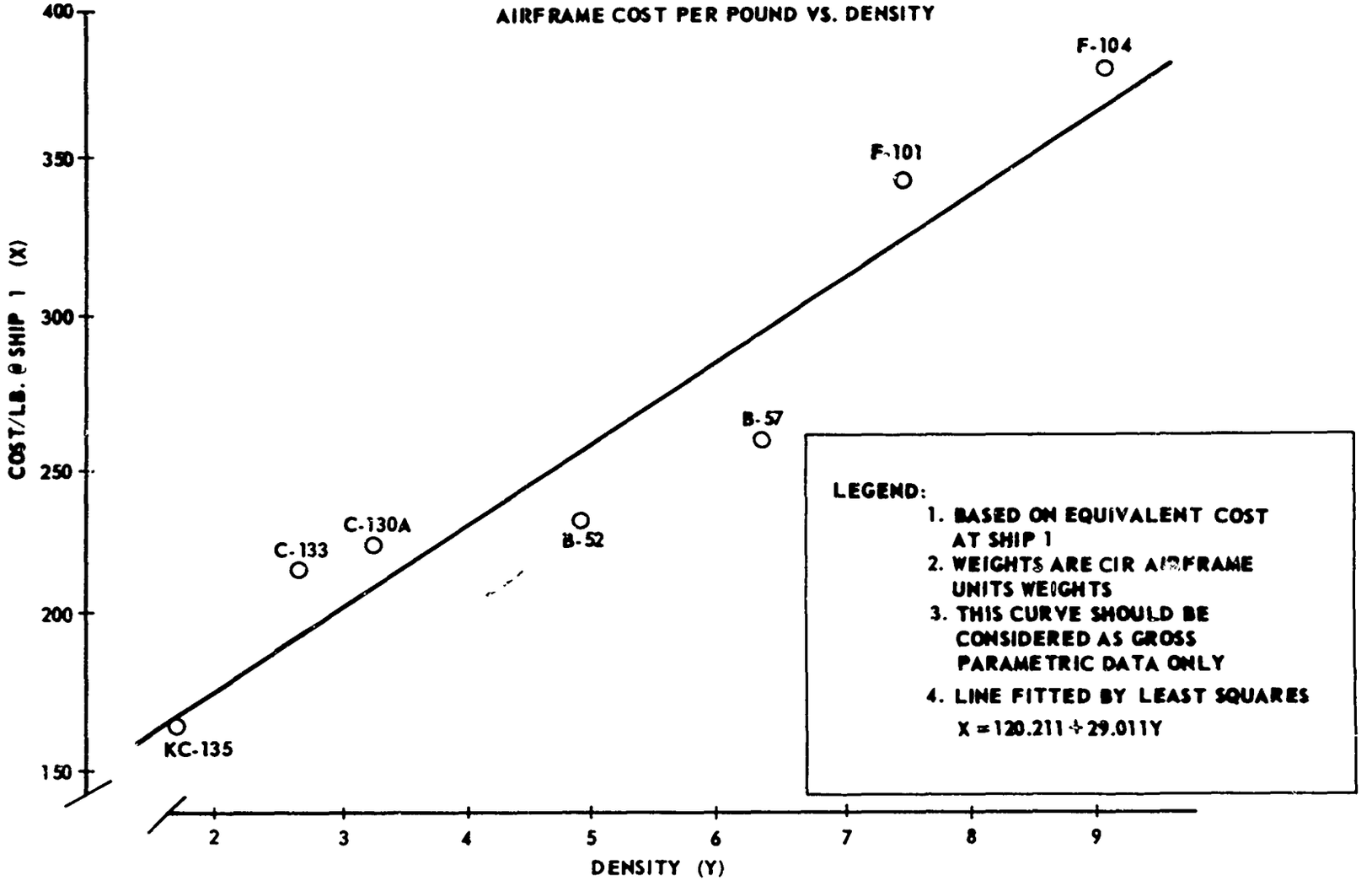
More detailed discussions of CERs can be found in Appendix B.

*Note: It should be noted that while the least squares fit of this line is good, it has been classified as gross parametric since validation of the resource expenditure data source was not possible.

EXHIBIT III-8

TYPICAL COST ESTIMATING RELATIONSHIP

AIRFRAME COST PER POUND VS. DENSITY



III-6-b Simple Analogue

The simple analogue technique is based on construction of CERs using cost information from logically similar items. The classic examples in the aerospace industry are the use of (1) aircraft cost information to estimate the costs of missiles and (2) information on prop driven transport aircraft to estimate costs of jet transport.

The simple analogue is used when there is little or no historical information available in the specific item or closely related items and/or when the cost estimating task schedule precludes an extensive cost information research effort. In these estimates the choice is between an estimate prepared by skilled cost analysts and cost estimators and a decision (which may have extensive cost ramifications) being made without specific cost inputs.

III-6-c Engineering

Engineering approaches to cost estimating are based on extensive knowledge of the product characteristics and, hence, are applicable only to items which are near or in the production phase. Engineering estimates rely on detailed knowledge of the product, the production processes, and the production organization.

III-6-d Expert Opinion

Expert opinion is used in construction of most CERs particularly to check the behavior of the relationship when it extends significantly beyond the data base or where the data base is too small to have statistical significance.

Another use of expert opinion is to adjust a CER to reflect costs of another technology, such as using a CER developed for a mild steel structure to cost an item with high tensile steel.

The pitfalls in use of CERs must be well known to the analyst who prepares them since only he can evaluate the limitations of the data. However, these pitfalls are more appropriately discussed in the subsequent chapters.

III-7 COST ANALYSIS DOCUMENTATION AND PRESENTATION

The documentation and presentation of cost information should be relatively standardized to facilitate their use and analysis. The comments here reflect the experience gained in lengthy and detailed cost analysis and cost estimates.

III-7, Cost Analysis Documentation and Presentation

Cost analyses are best documented in two volumes or reports. The first, a Summary Report, is prepared for management consumption. This report must support directly any cost exhibits specified in the cost analysis request. Exhibit III-9 presents an outline of a typical Cost Analysis Summary Report.

The Working Report (s) presents the details of the cost analysis; hence, it is the basic mode of communication between cost analysts and between the cost analyst and the cost estimator. This report should be the subject of detailed validation, evaluation and review rather than the summary report. The Working Report should be prepared in the format indicated in the outline presented in Exhibit III-10.

III-8 COST ANALYSIS QUALITY CONTROL CHECKLIST

The purpose of the Cost Analysis Quality Control Checklist is to provide in ready reference form a concentrated evaluation of the quality of a cost document and to encourage a structured review of the cost analysis task both during the analysis and at completion. Exhibit III-12 presents a two-page checklist. One of these forms is prepared for each item in a study or for complex studies, such as the Main Battle Tank, for each major work breakdown structure element.

The first page of this form is rather straightforward. The reverse side utilizes some technical terms referenced previously in this handbook. The following comments relate directly to the numbers circled in Exhibit III-12.

1. The WBS levels will be as indicated in Exhibit III-6.

2. Item status will be the developmental stage of the item in accordance with "Reporting of Research, Development and Engineering Program Information," DoD Instruction 3200.6 (Ref.III-10) relative to the date of the key cost information document.

3. Data classification provides for the identification of the key cost document according to the level of fiscal responsibility of the preparing organization.

4. Character of the data is an indication of the cost analyst's opinion of the preparing organization's intended level of credibility. The definitions of gross parametric, semi-definitive and definitive were presented and discussed in Section II-1.

EXHIBIT III-9
SUMMARY COST ANALYSIS REPORT OUTLINE

Cover Page

- Name of Study
- Prepared for _____
- Prepared by _____
- Participating Organizations
- Study Directive (In bibliographic style)
- Approving Authority (Name rank and/or title and signature)
- Date of Approval

Contents

Introduction (1 to 3 pages)

- Purpose of the Study
- Key Ground Rules
- Critical Constraints
- Key Assumptions

Work Breakdown Structure

Items and Conditions Included

Methodology (1 to 2 pages)

Presentation of Study Results (2 to 4 pages)

Conclusions (1 to 2 pages)

Recommendations (1 page)

Note: The page count presented here is for guidance only.

EXHIBIT III-10

COST ANALYSIS WORKING REPORT OUTLINE

Cover Page
- Title
- Prepared for _____
- Prepared by _____
- Participating Organizations
- Approving Authority (Name, rank and/or title and signature)
- Date of Approval
- Key Analysts

Cost Analysis Quality Control Checklist (See Exhibit III-12)
Contents
Introduction
- Purpose of Study
- History of Study
- Brief Description of Items or Systems (Including developmental status)

Study Ground Rules
Constraints
Assumptions
Methodology
Information Summaries
- Product Characteristics (See Exhibit III-11)
- Schedule (Tabular or graphic)
- Resource Expenditure (Similar to Exhibit III-11)
- Cost Document Status (Narrative)

Reference Unit Costs
Validation Reports
Estimating Relationships (Used and/or derived)
Results
Conclusions
- In Response to Study Directive
- Relative To Cost Analysis And/Or Cost Estimating

Appendixes
- A - Study Directives, Instructions, and Correspondence
  A bibliographic list by date of receipt or date of origin for outgoing documents followed by copies of study.
- B - Bibliographic List of Cost Information Survey.
- C - Bibliographic List of Interim Reports.
- D - Summary Report
  (Annotated as to Working Report source for each item of cost information)

EXHIBIT III-11

TYPICAL PRESENTATION OF PERFORMANCE CHARACTERISTICS DATA

PERFORMANCE CHARACTERISTICS
STUDY: _____

ANALYST: _____ DATE _____

VERIFIED: _____ DATE _____

	Characteristics	Units	Item Name		Item Name		Item Name		Item Name	
			Value	Source	Value	Source	Value	Source	Value	
1	Number of Channels	Number								
2	Carrier Freq(Primary)	Hertz								
3	Band Width	△ Hertz								
4	Range	Miles								
5	Input Power	Kilowatts								
6	Output Power	Kilowatts								
7	Range Error	Yards								
8	Bearing Accurracy	Degrees								
9	Elevation Error	Degrees								
10	Pulse Repetition Freq	Pulses per Second								
11	Reliability	Percent								
12	Detection Threshold	Eqv. Tgt. @-yds.								
13	Antenna Gain	Decibels								
14	Antenna Speed	Degrees/Second								

COST ANALYSIS QUALITY CONTROL CHECKLIST

Study Title. _____ Date _____

Item _____

WBS Element: _____

Analysis Request:

Purpose:

Reference Documents*

Analysis Documentation*

Summary Report:

Working Report (s):

Analyst _____

Name | Title | Office | Phone

*In bibliographic style, use additional sheets if necessary.

A

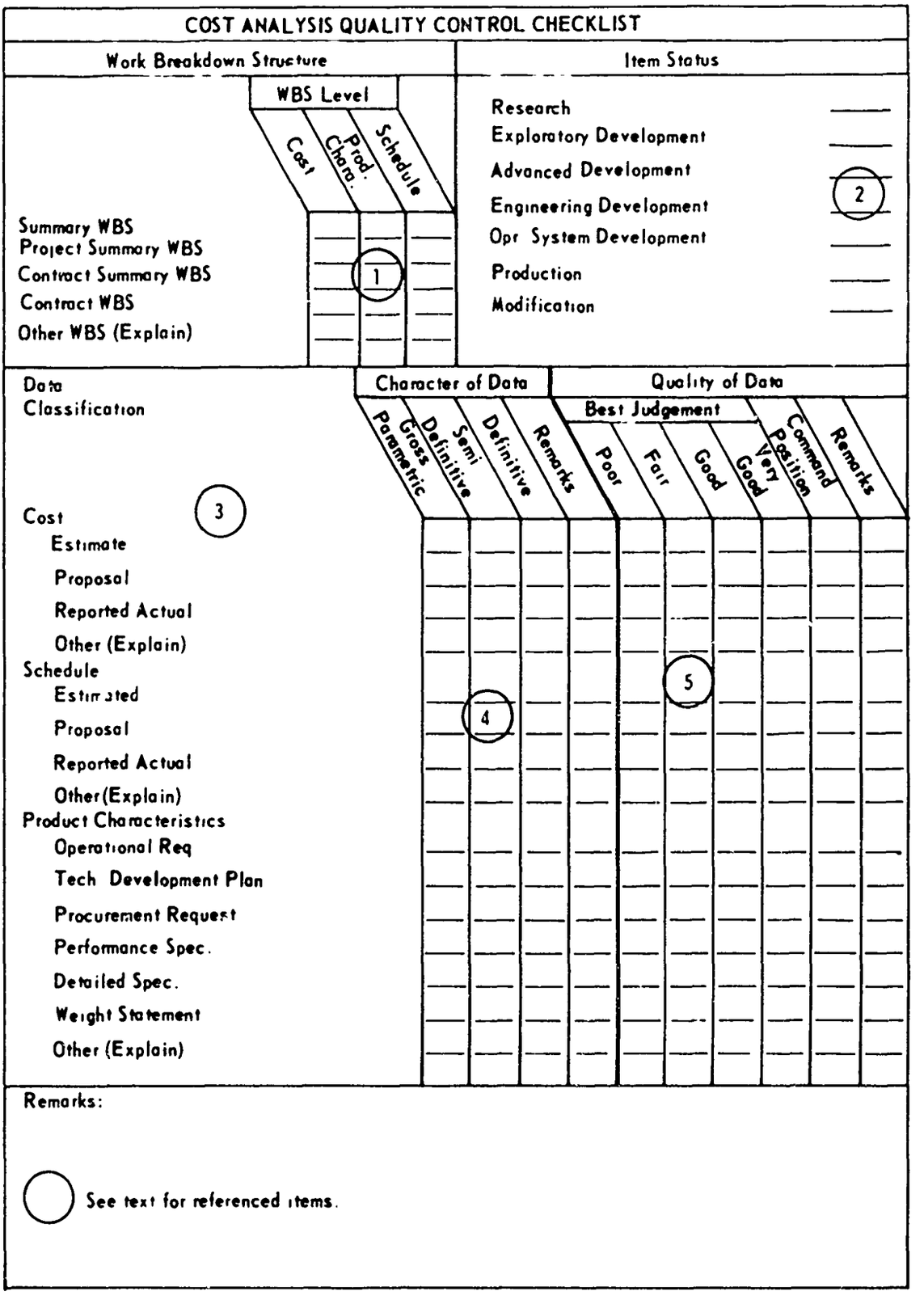


EXHIBIT III-12
COST ANALYSIS QUALITY CONTROL CHECKLIST

B

5. Quality of data is an indication of the cost analyst/cost estimator's opinion of the credibility of the information within the constraints of item 4 above. Two major headings are presented:

   - Command position - The information reflects the official position of the command or subcommand.
   - Best judgment - The information does not have the recognition as official position of the command or subcommand. This major grouping is further subdivided into four qualitative groupings as follows:
     - Very Good - Good quality data in most ranges
     - Good - Good quality data in most significant cases.
     - Fair - Data limited, and because of its source or date of origin not considered of good quality.
     - Poor - Estimates based on knowledge of other systems and rough comparisons with related data.

A checklist such as the above is as good as the utilization made of it. If it is a performance document completed because it is required, its value will be quite low. However, if it is critically reviewed at every echelon and possibly made an item in performance reviews, its value will be greatly enhanced.

The cost analysis will be only as good as the historical data used in its preparation and the ingenuity of the cost analyst to incorporate all possible significant elements.

Chapter IV

COST ESTIMATING TECHNIQUES

Cost estimating has been defined as the "process of producing an approximate cost..." The accuracy and level of detailed knowledge available on the item to be estimated varies and, thus, affects the character, level of detail and accuracy of the estimate. As discussed in Chapter II, the estimates can vary from the gross parametric estimates used in early feasibility studies to the detailed source selection type Independent Government Cost Estimate. Throughout this wide range of estimates (wide in terms of calendar time and detail) a progressive structure should be developed. It is progressive in the sense that the later estimates will be more detailed, but the last estimate will look very much like the first and can be compared at some level of detail below the total. This implies that the cost estimator can approximate the final cost structure very early in the evolution. This can be done and should be done both for the purpose of achieving comparability, and to provide a checklist to assure that no part of the product being estimated is overlooked.

This chapter will discuss the considerations in estimates which are made late in the evolution of estimates since these are more descriptive. Early in the evolution, many of these considerations will not be significant; yet the cost estimator should realize that eventually the structure and the CERs must accomodate them.

This chapter points out the various limitations of CERs to highlight considerations to be addressed in their selection. This could be considered to be negative in tone; however, it should not be considered a deprecation of CERs, but rather a warning that the best CERs can yield bad estimates when not used properly. Properly constructed CERs, used by skilled cost estimators, can approximate the future with sufficient accuracy for the particular application, if the item to be estimated and the data upon which the CERs are based, are compatible in the following areas:

- Product characteristics
- Economic time frame
- Competitive environment
- Procurement package
- Production technology
- Production rate
- Production quantities (including external demands)

It must be remembered that all of these factors are essentially built in or implied in a CER; however, complete compatibility is not a prerequisite for construction and use of a CER.

Inherent in the phrase "sufficient accuracy for the particular application" is the assumption that estimates will be updated at each stage in the evolution of estimates (see Exhibit II-1). Obviously, costs used in a gross parametric special study cannot be as precise as those derived for an Independent Government Cost Estimate used in source selection. By the same token, but to a lesser degree, variations can be expected between successive steps.

There are two types of estimates which are defined and should be clearly identified in the estimate documentation;

- Technical Estimate* - The technical estimate is the estimate of a precisely described task. This type of estimate is normally used for systems analyses, decision making and modeling. It is also normally used for contractual purposes, because contracts are written for a specific product on a specific schedule, and any changes made are handled through changes to the contract. This estimate includes economic escalation, if appropriate to the study. The technical estimate should be auditable back through the calculations to the cost information sources.
- Conditioned Estimate - The conditioned estimate includes adjustments to the technical estimate to allow for such factors as product improvement, which are not specified in a normal technical task description; for technical difficulties; and for technical estimating accuracy. This estimate may include both quantifiable and subjective adjustments, and is normally used for funding purposes.

The primary focus of this chapter is upon the technical estimate, particularly as related to contracting, for the estimating procedures are the most detailed at this level.

IV-1 COST ESTIMATING RELATIONSHIPS

The "technical estimate" is a formalized estimate which can be documented as the output of CERs. These may include statistical CERs, such as those described in Section III-6; expansion of CERs to recognize facets

* The term "technical estimate" may be misleading since it implies scientific derivation. Cost estimating, however, uses a large measure of subjective judgment along with its scientific methods.

of the product to be estimated which were not previously significant; and possibly CERs based upon structured logic to fill voids in the data which cannot otherwise be filled. The technical estimate is a single point estimate of the "if A, then B" type of logic: if A is the product, schedule, and quantity, then B is the cost. The following paragraphs present the major considerations in selection of CERs to provide the technical estimate.

IV-1-a Factors to be Considered in Selection of CERs

The widespread reliance upon CERs in the form of cost factors, equations, graphs, etc., attests to their value. CERs have become a "language" with which intelligence derived in the cost analysis process is transmitted to the data bank, and ultimately, to the cost estimator. Each CER is a unique combination of factors drawn from recorded history using the combination of assumptions and conditions deemed appropriate by the cost analyst.

This "meaning" of the CER is determined by the cost analyst and the data available to him. The cost analyst relates the data to some basic reference point--the lowest common denominator which he can derive. However, it is seldom possible for the cost analyst to anticipate all the requirements of a cost estimating task.

In preparing a CER, the cost analyst must be aware of factors which affect both the x and y axes of the graph. Among the factors which affect the cost axis (or y axis) of such a graph are those discussed below.

- Economic Time Frame-* Has the CER been constructed to provide a cost estimate as of a specific calendar date for the economic value of the dollar, or has some inflator been built into the CER? If the latter, is it compatible with the time frame set forth in the cost estimating task?
- Competitive Environment- Does the CER data base reflect the same level of competition (advertised, sole source negotiated, selected bidders, etc.) as expected for the items being estimated?
- Procurement Package- How are the support hardware (support equipment, spares and repair parts) and software (systems test and evaluation, systems engineering/ project management, training, data, guarantees and

*Note: When employing statistical techniques for short or long term estimates, the analyst should be aware of error due to unpredictable factors. Estimates based on long term economic trends may not be applicable in the short term since fluctuations in economic factors cannot be measured and projected accurately.

warrantees, etc.) handled? How is test hardware covered in CERs? Are these compatible with the cost estimating task conditions?

- Production Technology - Does the item being estimated include significant effects of a developing technology where production costs change rapidly with time, such as in the electronics industry? Will the item require introduction of new production technology such as the use of aluminum or stainless steel honeycomb on early supersonic aircraft or a harder steel in the Main Battle Tank?
- Production Run - Does the CER reflect the general production run (number of units produced) required for the item being estimated?

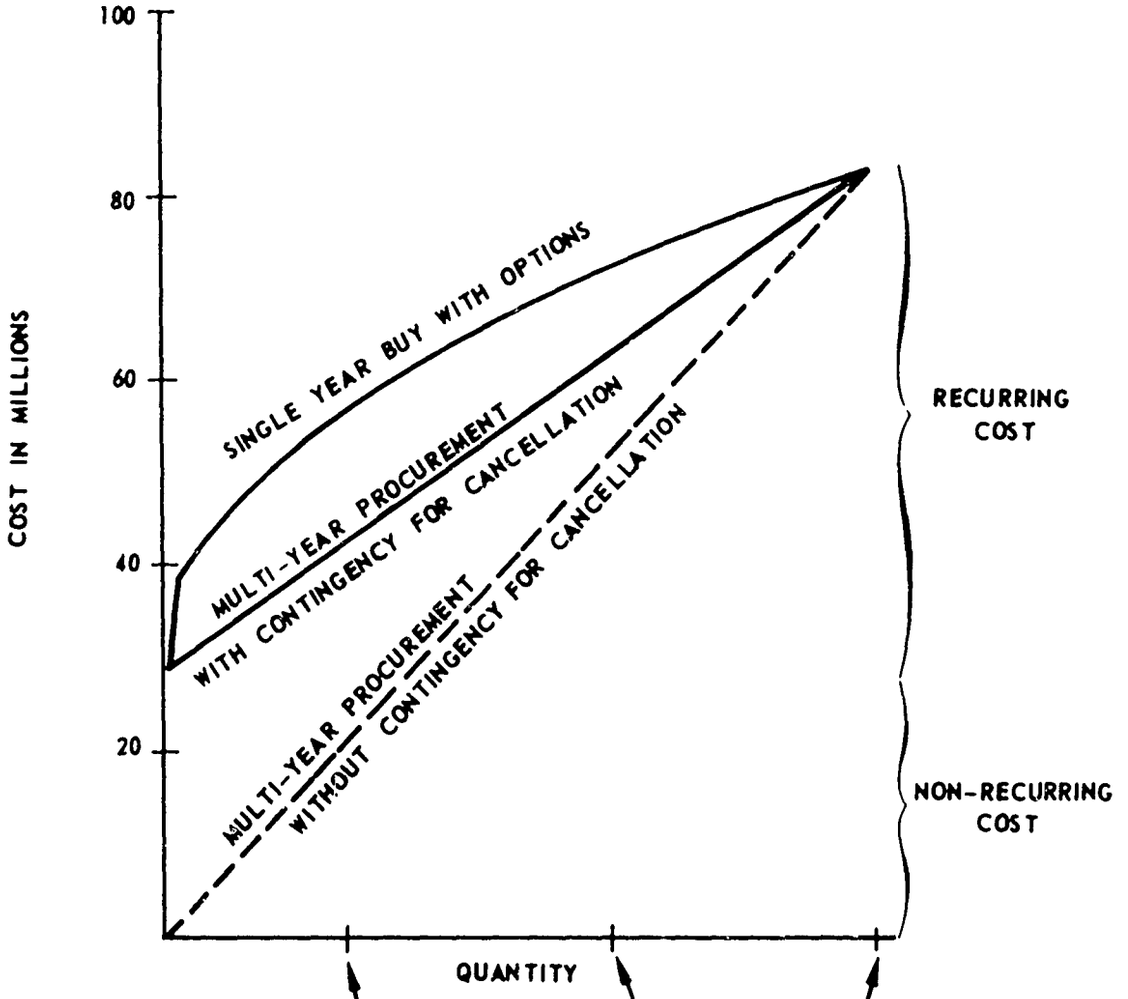
Among the less obvious factors are the compatibility between the data base and the cost estimating task in the areas of:

- Logistic Support Plan - The techniques for provisioning of spares, number of months of supply or the prescribed operating level, etc. may be changed significantly from that in the data base.
- Design Standards in Reliability, Maintainability, Quality Assurance, Etc. - These relatively new disciplines have increased the demands placed on designers, and may have introduced characteristics which were never documented in the data base.
- Test and Evaluation Criteria - As products have become more complex the requirements for demonstration have become more stringent.
- Accounting Principles - CERs are often based upon direct labor charges; however, direct charge and overhead definitions can vary widely between contractors, and contracts; and the method of contracting; (i.e., CPFF, FPI, FFP, multi-year procurement, single year buy, etc.) can dictate rather significant changes in accounting principles. For example, Exhibit IV-1 presents a comparison between a multi-year procurement and a single year buy/with options for follow-on years. It should be noted that the only difference assumed in construction of this exhibit is the method of contracting. The single year buy/with options is a "pay as

EXHIBIT IV-1

ANNUAL FUNDING

THREE CONTRACTING METHODS



ANNUAL FUNDING (IN MILLIONS)	FIRST YEAR BUY	SECOND YEAR BUY	THIRD YEAR BUY	TOTAL COST
SINGLE YEAR W OPTIONS	57	15	10	82
MULTI-YEAR PROCUREMENT WITHOUT CONTINGENCY FOR CANCELLATION	20	31	31	82
WITH CONTINGENCY FOR CANCELLATION	42	20	20	82

you go" type of contract and multi-year procurement is governed by the ASPR provision 1-322.2(b) which states:

(iv) "a provision that the unit price of each item in the multi-year requirement shall be the same for all program years included therein."

A substantial difference remains even if the annual funding includes the cancellation ceiling in accordance with subparagraph 1-322.2(c) which states:

"In determining cancellation ceilings, the contracting officer must estimate reasonable preproduction and other non-recurring costs to be incurred by the prime or subcontractor which would be applicable to and which normally would be amortized in all items to be furnished under the multi-year requirements."

- Plant Load - The volume of work in process (plant load) has an effect on the overhead distribution. The higher the plant load the lower the overhead rate. This is a particularly important consideration for procurements in industries which have a few large contracts in process in one plant.
- Geographic Location - Labor productivity and transportation rates vary quite widely between geographic areas.
- Production Levels - Differences in production runs can have a significant effect upon both non-variable and variable costs. Where a long production run is envisioned, more effort is spent in planning and tooling which results in higher non-variable costs and lower unit variable costs. The reverse is true of short production runs. Care must be exercised where there are considerable differences between the production runs of data base items in the CERs and those of the item being costed.

All of these factors affecting the cost axis may not be of significance in selection of CERs early in the evolution of estimates (see Exhibit II-1); however, the nearer the cost estimate approaches the contracting environment, the more important consideration of these factors becomes.

Two major technical questions related to selection and use of a CER are these:

- Will the type of data used in construction of the CER provide a contribution to the cost estimating process? As indicated above, there may be many reasons for modification of a CER, some of which must draw upon information far afield from the products cited in the cost estimating task. However, if a valid thread of logic can be woven to introduce a factor which will improve the accuracy of the estimate, that factor should be incorporated.
- Does the construction of the CER properly reflect the characteristics of the cost estimating task item? Each cost estimating task has some unique characteristics which require special treatment. Perhaps some performance or physical characteristics is emphasized or pushed to the edge of the state-of-the-art, thus, introducing a bias away from the configuration of the available CERs. Seldom is there a ready-made CER; some reconstruction is normally required to make the available CERs suitable for the cost estimating task. This fact of life has lead to the blurring of the distinction between cost analysis and cost estimating.

IV-1-b Interim Report

Concurrent with this evaluation of the available CERs, the cost estimator should determine:

- The requirement for new CERs which can be generated from the existing data base or possible additions to the data base.
- The modifications of CERs which must be accomplished on the basis of expert judgment and logic.
- The areas where no CER currently exists.*

*Note: Cost estimating tasks should be answered with a complete estimate, that is, no elements left with the notation "Not Estimated." Where no CERs currently exist, the cost estimator should construct his best estimate using the information available to him and present it with appropriate notations.

The end of the first evaluation of the possible CERs provides an excellent point for an interim report to document the problems which have occurred. Appendix C presents an excellent example of an evaluation made at approximately this point in a Main Battle Tank cost estimating task.

IV-2 PURPOSE OF THE ESTIMATE

The purpose of cost estimating is to predict the future so that it may be examined in view of demand for resources. This examination may be oriented toward relative accuracy or accuracy in magnitude. For example:

- Selection Between Alternatives: This purpose uses estimates along with measures of effectiveness (or benefit) to decide which of a number of alternatives is the better. While this selection implies a decision to expend resources, no specific amount of resources are allocated. The emphasis here is on relative resources requirements rather than the magnitude required. Thus, for this type of decision making it is important that the cost estimates be similarly biased and possess a comparable measure of central tendency. For this purpose a technical estimate is adequate.
- Allocation of Resources This purpose uses estimates in the "real world" context of dividing up a specific amount of resources (hardly ever an adequate amount). Thus, it is important that the estimates be precise, particularly in the magnitude of resources required.

The first is oriented toward selection of the course of action while the second is oriented toward defining the resource requirements at each step such as fiscal year funding. The second should be oriented toward assuring that resources are available to complete each step, hence, is conditioned by the "real world", considerations of potential overruns, technical charges, and statistical error.

IV-3 CONDITIONED ESTIMATE

The technical estimate has been discussed in the first section of this chapter and the considerations in its derivation in Section 2. This section discusses the considerations for conditioning that estimate for the "real world" conditions of resource allocations (funding).

IV-3-a Statistical Variations

The source of the technical estimate is a set of CERs. These being essentially statistical derivations, they have some inherent variations. The cost estimator should develop some measure of the expected variation around the "technical estimate" to assist in preparation of the "conditioned" estimate, as described below.

There are several statistical techniques which can be used to determine the distributions for cost estimates. Ref. IV-3, describes the use of the beta distribution in cost estimating. Use of this technique, however, requires a high degree of statistical sophistication and the availability of a computer.

Another method of measurement is to use the normal distribution, which is symmetric, easily described, and well documented in statistical literature. If the technical estimate is considered the mean of a normal distribution, the estimator, possibly relying on subjective judgment, can determine the amount of one standard deviation from the mean. Thus, the peakedness of the normal curve for each estimate can be stated simply and the factor can be given as O.XX standard deviation.

For example, the table below illustrates the conservatism; that is, the percent of possible estimates falling below the "conditioned estimate" for a given "contingency factor."

Contingency Factor	Expected Percent of Actuals Below "Conditioned Estimate"
.0	50
.1	54
.2	58
.3	62
.4	66
.5	69

IV-3-b Task Changes

In addition to statistical variations, there is another source of error, that of understatement of the task in terms of changes in product characteristics and schedules. Traditionally this has been the major source of underestimates and the attendant overruns. Adjustments for undefined task changes require close coordination with technical and program control personnel.

While this is a subjective judgment, it is an important element in estimates which are used for resource allocation. Statistical variations can be expected to washout over a large number of estimates but the magnitude of a technical program is very seldom overestimated; hence, there is little opportunity for the overestimates to washout the underestimates.

It is emphasized that costs cannot be determined purely by statistics. Subjective judgment based upon thorough familiarity with the system being costed must be employed. Although statistics may indicate causality, the estimator must examine and understand the logic of the relationship to avoid accepting results which might be mathematically correct, but, in other significant aspects (technical or otherwise) unreasonable.

IV-4 TRANSLATION OF ESTIMATES INTO TIME PHASED RELATIONSHIPS

Estimates are normally derived on the basis of a cost/quantity relationship or a total cost of a task. Such a cost is adequate for many systems analysis or cost-effectiveness studies; however, in the AMC environment the capability must also exist to place this estimate in the context of time.

IV-4-a Time Phasing Bases

The seven most significant bases for distribution of costs over time are as follows:

- Obligation Authority - "Any kind of congressional or administrative authority to incur obligations, whether or not this authority carries with it the authority to make expenditures in payment thereof," (Ref. IV-1).

  - Contractor - Cost charged or recorded as of the contract date or award letter date.
  - Government - Costs charged or recorded by year of appropriation. The entire annual authority thus established is the Total Obligational Authority (TOA).

- Disbursement - "The amount of "expenditure" checks issued and cash payments made," (Ref. IV-1).
  - Contractor - Costs charged as of the date of the contractor's payment of subcontractors--labor, vendors, et al.
  - Government - Costs charged as of the date of the governments payments to the contractors.

- Applied Cost - The cost of goods and services charged at the time they are placed in use or consumed.
  - Contractor - Costs charged or recorded as of the date work is applied to the contract.
  - Government - Costs charged or recorded as of the date of issue to using organization.

- Production Release - Costs charged or computed at the time a unit or lot is released for production. Costs are seldom recorded on this basis. The production release date (or production lead time), however, is often the key point in relating costs to schedules.

- Delivery Cost - Cost computed or charged as of the date of delivery to the customer.

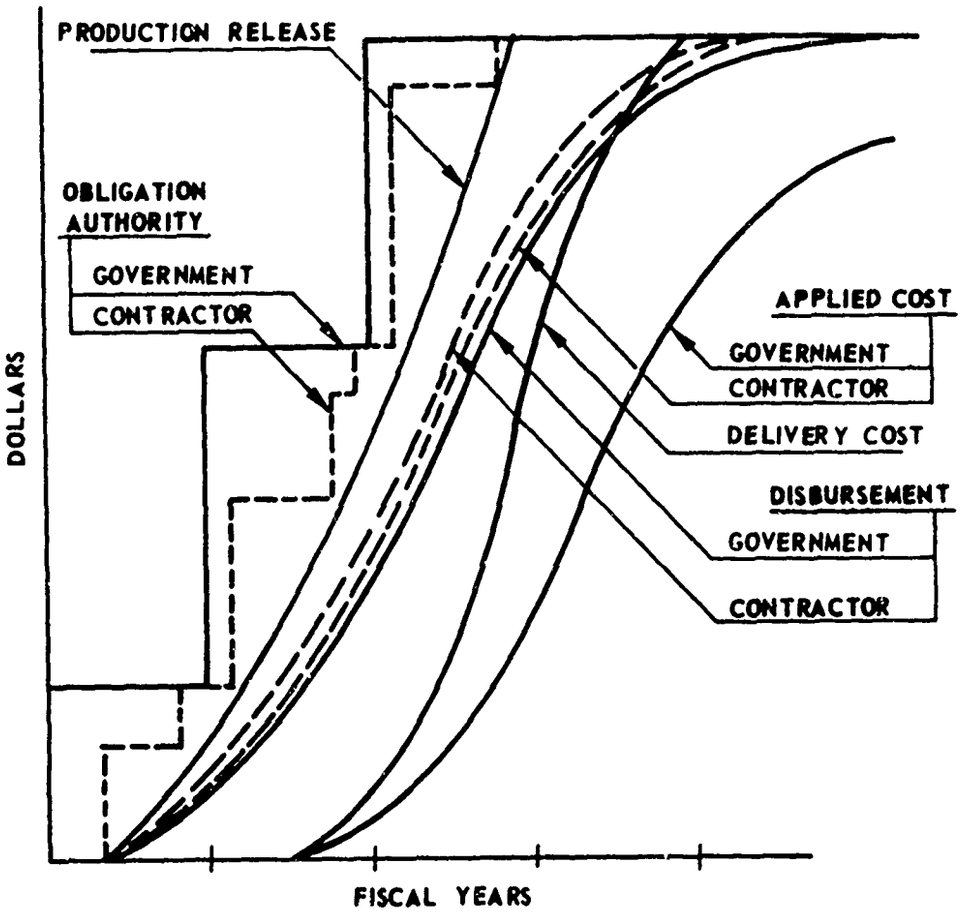
Exhibit IV-2 presents a generalized picture of relationships. The precise nature of the lead-lag relationship is peculiar to a given set of appropriations, types of contracts, industry practice, etc.

It should be noted that time phasing of the estimate has not changed its magnitude.

The particular time phasing basis to be used in a cost estimate

EXHIBIT IV-2

TYPICAL TIME PHASED COST RELATIONSHIPS



is stated or strongly inferred in the cost estimating task assignment. For example:

- Terms such as budqetary, FYDP, and funding, imply a Government Obligation Authority estimate.
- Where estimates are to be compared with contractor's accounting reports and billings, the cost estimator must determine, line by line, the time phased basis reflected in the contractor's report.

A typical time phasing sequence is presented in Exhibit IV-3. In this example the delivery curve is given. The cost estimator must then determine, either from experience or by direct statement, that in order to deliver the quantity A of items by time B, the manufacturer must release production by time C and the contract go-ahead (Contractor Obligation Authority) must be given by time D. The estimated cost of quantity A is Point E on the Cost Quantity Curve. Therefore, since the contract cannot be written without Government Obligation Authority, the amount E must be funded in Fiscal Year 1. Quantities F and G are treated similarly.

Such time phasing requires an initial reference point for placing the estimate on the calendar. The criteria for selection of such a reference point are that:

- It is readily available to the cost estimator either by direct statement or by rather direct implication.
- It has a rather stable relationship with the other time phased bases.

The best candidate for this reference point is the delivery cost curve.

IV-4-b Techniques for Time Phasing

There are two basic approaches to establishing this time phasing:

- Specific lead-lag times.
- Work flow distributions.

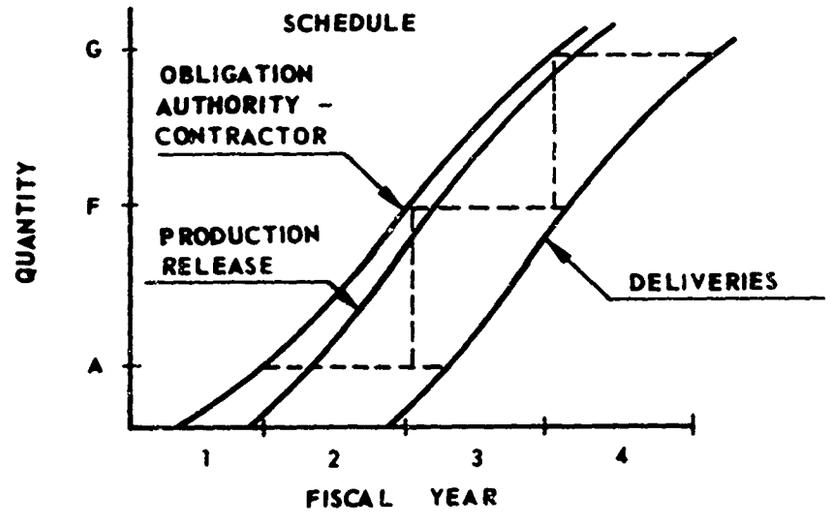
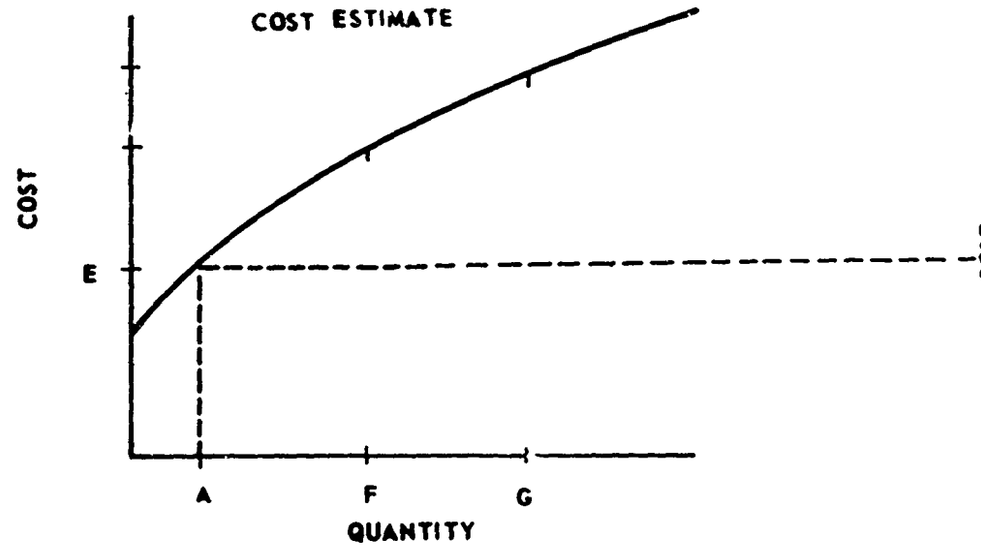
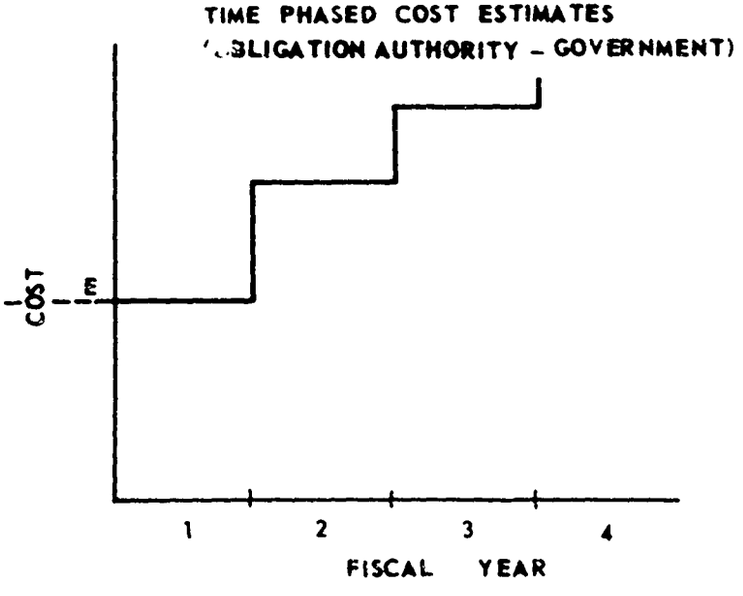


EXHIBIT IV-3

TYPICAL TIME PHASING SEQUENCE





IV-4, Translation of Estimates Into Time Phased Relationships

The specific lead-lag method may employ a specific period of time such as procurement lead time and contracting time to lead a specific date or event. The specific lead-lag times are particularly good in time phasing authorizations where the time phasing is a step function. Where the time phasing is actually a non-linear distribution over time (such as a disbursement or contractor's applied cost) a work flow distribution should be used. Two such distributions are presented in Exhibit IV-4. The first, "Percent Effort/Actual Time," requires less data and is less complex computationally and, logically,* a little less accurate. It requires:

- Cost for each unit (or lot) to be produced.
- Single schedule event (such as delivery) for each unit (or lot).

The second, "Percent Effort/Percent Time," is more complex computationally, requires one additional bit of schedule information (production release) and logically is more accurate

It should be noted that either of these curves can be extended beyond the event, as indicated by the crossing of the expenditure curves over the delivery curve in Exhibit IV-2.

The reader should also note that the Government Applied Cost has not been addressed because the precise method of calculation cannot be defined until the procedures are developed for implementing the Resource Management System in PEMA areas. However, it is unlikely that any of the above techniques will be adequate.

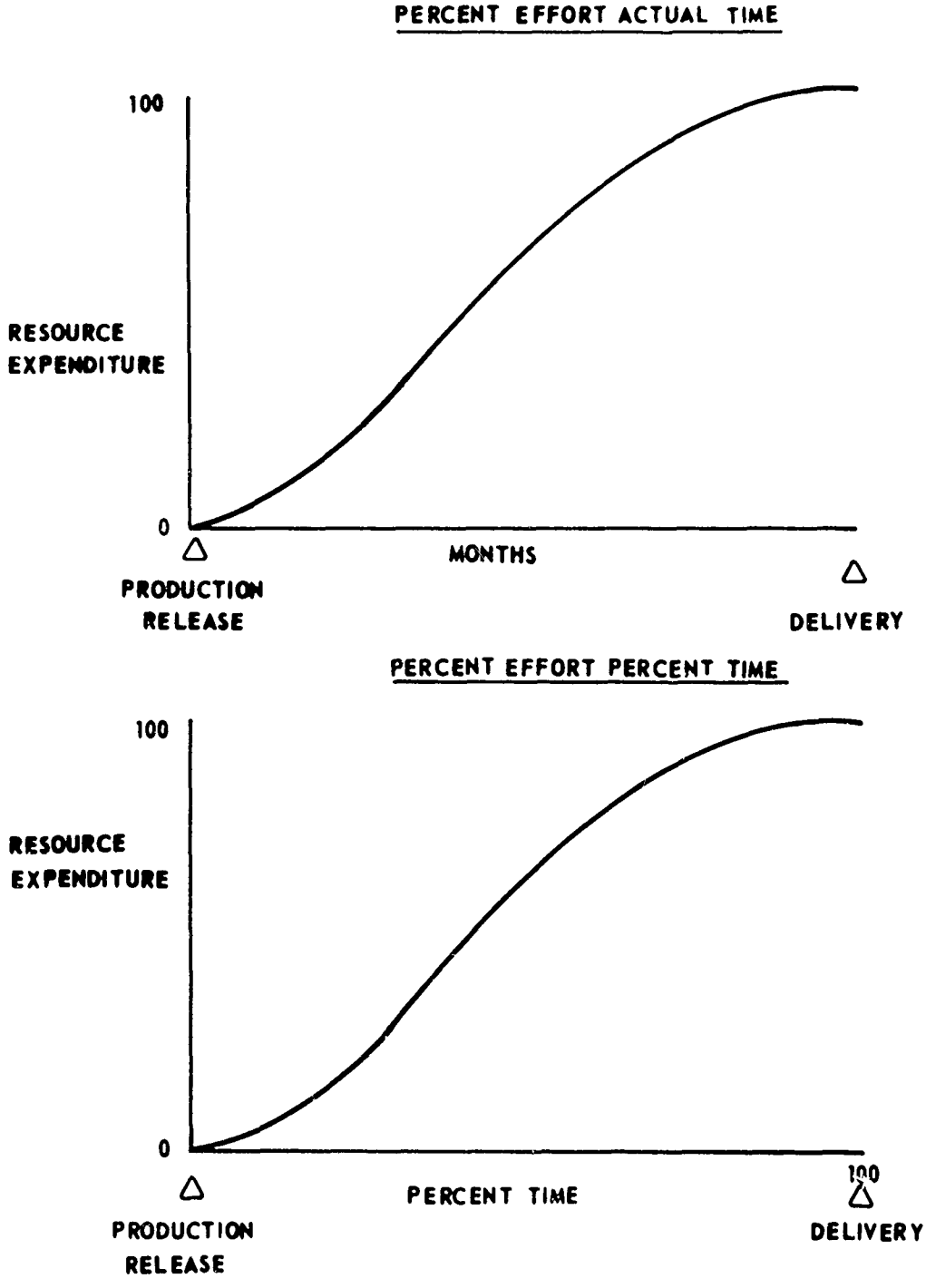
To a major extent the cost estimates within AMC will be on an authorization basis, that is, estimating the obligation authority required to permit contracting for deliveries as specified for a force plan.

Generally, PEMA obligation authority is time phased in accordance with delivery date, less production lead time and contracting time. In some special circumstances this is modified

* The conditional term, logically, is used here since accuracy is as much, if not more, a function of information than of technique.

EXHIBIT IV-4

TYPICAL WORK FLOW DISTRIBUTIONS



to permit procurement of long lead time items a year prior to authoriztion of procurement of the complete item. Exhibit IV-1 presents one example of the effect of ASPR prescribed accounting principles upon the time phasing of an authorization estimate. The other major application of time phasing is to reverse this relationship and determine the effect of budget costs upon the delivery of items.

The other relationships are used in special cases where the cost estimator must provide an estimate of the cost-to-complete in a manner compatible with a specific set of data (see Section IV-6, for example) or in times of expenditure restrictions to maintain a close estimate of the demands to be placed upon the Treasury. However, this time phasing of monies could become an important facet of cost estimating, when the Resource Management System (Ref. IV-2), in its currently envisioned form, is extended to the PEMA appropriation.

IV-5 COST ESTIMATE DOCUMENTATION AND PRESENTATION

The Cost Task Summary Sheet presented in Exhibit IV-5 is designed to provide a ready reference for review. This form should be completed at the outset of the cost estimating task and updated as significant changes are received.

The required format for presentation of a cost estimate is directed, normally, by the cost estimate request. Exhibit IV-6 presents an extract from the Army Materiel Plan (DA form 2624-2) which is typical of the requested level of detail for a cost estimating task. Such a level of detail is adequate for formal documentation purposes; however, it is not particularly responsive to the communication between cost analyst and cost estimator. For this purpose the following two documents should be provided:

- Summary Report - This document presents the major facets of the estimate and will be suitable for presentation at higher headquarters as a justification document. It should follow the format described in Section V-7.
- Working Report - This document presents the full details of the estimate in such a manner that another cost estimator or cost analyst can trace both the logic and the mathematics

EXHIBIT IV-5
COST TASK SUMMARY SHEET

COST TASK SUMMARY SHEET

Title

No: _____

Date:

Assigned _____

Due: _____

Assigned to: _____

Estimate Request:

Purpose:

- Independent Government Cost Estimate ☐
- Five Year Defense Program ☐
- Budget ☐
- Special Study ☐
- Other (Explain) ☐

Narrative:

Estimate Ground Rules

Data / Name of Item / Number						
	Value	Source	Value	Source	Value	Source
○ Production Run						
No. of Units						
Contract Date						
Funding FY						
Prior Prod						
○ Cost Base						
FY____ $						
Design Freeze Date						

Reference Documents*

*In bibliographic style, use reverse if necessary

EXHIBIT IV-6

TYPICAL COST ESTIMATE PRESENTATION

EXTRACT

ARMY MATERIEL PLAN (PEMA ITEMS)
(DOLLARS IN MILLIONS)
(UNLESS OTHERWISE SPECIFIED)

SECTION II – MATERIEL PLAN

FY	PRODUCTION BASE SUPPORT A	ARMY PLANNED PROCUREMENT[2]		
		QUANTITY BY FY B	PROGRAM UNIT COST (IN DOLLARS) C	VALUE D
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				

[2] EXCLUDES OTHER CUSTOMER PROGRAMS.

DA FORM 1 FEB 66 2624-2

used in preparation of the cost estimate. A suggested outline for this working report is presented in Section V-7.

IV-6 VALIDATION OF COST ESTIMATING TECHNIQUES

Validation of cost estimating techniques takes eight modes:

- Validation of data base utilization - Has the cost analyst utilized the available data base to the fullest extent possible to support the cost estimate?
- Validation of the ground rules and assumptions - Has some directed facet or basic assumption made in the conduct of the study introduced some bias into the estimate? Are the production and delivery schedules realistic? Are there significant inferred ground rules or assumptions which bias or influence the estimate? Is the cost sensitivity analysis adequate?
- Validation of the CERs - Are the CERs properly constructed in both a mathematical and a logical sense? Are the product characteristics properly described? Are all WBS and Resource Categories addressed?
- Validation of trends - Are the technological and economic trends in consonance with those of applicable and allied industries? Are there good reasons for deviation from industry trends?
- Validation of the computations.
- Validation of the order of magnitude - Are the indicated costs reconcilable with costs of analogous items? Are the learning curve slopes realistic and well documented?
- Validation of the contingency factors - Is the contingency computation compatible with command policy? Is it necessary to include a contingency factor in this estimate?
- Validation of format - Is the report organized to present all of the required information in readily understandable terms?

COST ESTIMATE QUALITY CONTROL CHECKLIST

Study Title: _____ Date: _____

Item: _____

WBS Element: _____ _____

Estimate Request*

Purpose

Reference Documents*

Estimate Documentation*

Summary Report:

Working Report (s):

Estimator _____ _____ _____ _____

Name Title Office Phone

*In bibliographic style, use additional sheets if necessary

A

COST ESTIMATE QUALITY CONTROL CHECKLIST (Reverse)

Summary of Ground Rules:

Estimator's Evaluation:

Cost Handbook WBS Level (See Exhibit III-6)

	Data Base	Estimated Item
Cost		
Prod. Chara		
Schedule		

Estimate	Variance	Risk Factor

Estimate Status

	Data Base	Estimated Item
Exploratory Devel.		
Advanced Devel.		
Engineering Devel		
Opr. Sys. Devel.		
Production		

Data Base Estimate Comparison

	Data Base	Estimated Item	Remarks
Economic Base Year			
Competitive Environment			
Procurement Package			
Technology Base Year			
Production Run			

	Data Base			Output		
	Cost	Sched.	Prod. Chara.	Cost	Sched.	Prod. Chara
Character of Data						
Gross Parametric						
Semi-Definitive						
Definitive						
Remarks						
Quality of Data						
Command Position						
Best Judgment						
Very Good						
Good						
Fair						
Poor						
Remarks						

Remarks

EXHIBIT IV-7
COST ESTIMATE QUALITY CONTROL CHECKLIST

B

- Data Base - Indicate the average number of Work Breakdown Structure elements associated with the data base items, and reference, in Remarks, the Cost Analysis Task document which addresses this facet of the CER.
- Estimated Item - Indicate expected number of Level 2 Work Breakdown Structure elements.

- Technology Base Year - The Design Freeze Date (for rapidly developing production technologies only).
  - Data Base - Indicate the Design Freeze Date to which the CER data has been adjusted. If the CER data has not been adjusted indicate time span (earliest and latest year) and reference, in Remarks, the Cost Analysis Task document which addresses this facet of the CER.
  - Estimated Item - Indicate base year reflected in the estimate.

- Production Run - Number of items manufactured in a production sequence.
  - Data Base - Indicate average production run. Where the distribution of production runs is broad, indicate in Remarks, minimum, mode, and maximum.
  - Estimated Item - Indicate the assumed production run reflected in the estimate.

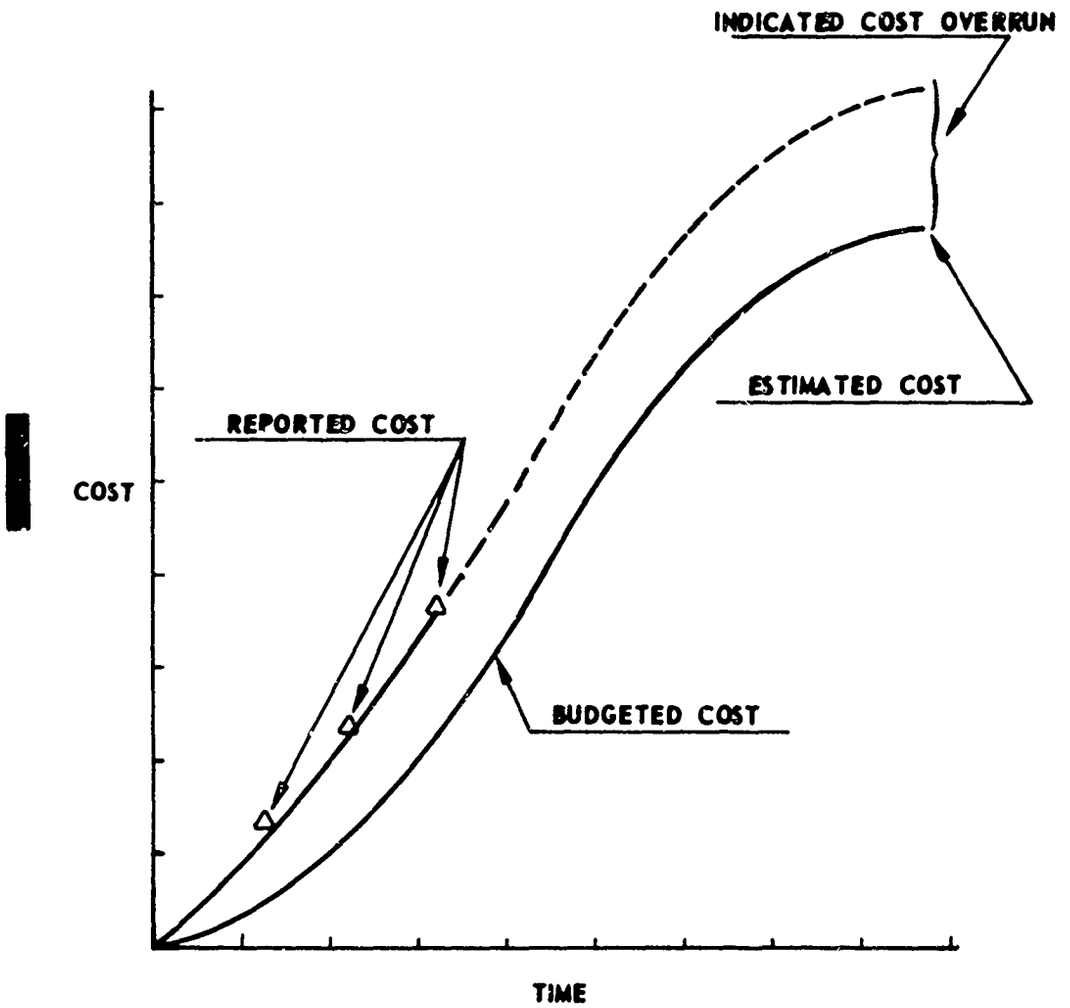
IV-7 SPECIFIC APPLICATION OF COST ESTIMATING IN COST ANALYSIS

Just as cost analysis supports cost estimating, the reverse is also true. This is particularly true of cost analysis of "in process" items. In this context it may be necessary to estimate the complete contract cost to understand and validate the reported costs to date.

Exhibit IV-8 presents a simplified example of the use of such a cost estimate. A more detailed presentation of a technique for accomplishing such an estimate is presented in Reference IV-4.

One of the principal uses of this type of estimating in support of cost analysis is in program control operations, which requires a detailed knowledge of the current status of the program and of the implications for the future.

EXHIBIT IV-8
TYPICAL COST ESTIMATE FOR USE IN COST ANALYSIS



Chapter V

COST ESTIMATING PROCEDURE

The three previous chapters have established respectively (1) the framework within which costs estimates are utilized, (2) the procedure for analysis of cost data, and (3) the techniques for making a cost estimate. This chapter will present the specific steps involved in accomplishing a cost estimate.

There are two systematic approaches to preparation of a cost estimate:

- Centralized Cost Estimating - where the cost estimates are prepared within the confines of a central group utilizing a previously acquired data bank.

- "Grass Roots" Cost Estimating - where the estimate requirement is parceled out to estimating groups associated with the responsible organizations such as the commodity commands.

Each of these approaches offers a significant contribution to cost estimating and cost analysis. In the early stages of development of an item, when quick cost estimates are required for special studies, the central group estimates are desirable and may be the only feasible source. As the evolution of estimates progresses toward the Resource Administration phase, where an estimate begins to take on the connotation of "I agree to do that specific job for this cost," it becomes important that the estimate:

- Be generated in the proximity of the responsible organization - (such as the commodity commands) implying control of the estimate by the responsible individual.

- Has the endorsement of the responsible individual, such as the systems/project manager or commodity manager.

The procedure described herein relates to the grass roots estimate. However, it also applies to centralized cost estimating where individuals may be thought of as estimating groups for responsible organizations.

V-1 LEVEL OF ESTIMATING DETAIL

The cost estimating techniques presented in Chapter IV may be utilized in either of the above approaches. The detail at which the techniques are applied, however, will ordinarily be at a higher WBS level in centralized

cost estimating than in grass roots cost estimating. Selection of the proper level for a cost estimate is conditioned by such factors as these:

- Objectives of the Study - Do the study objectives address relative demand or actual demand for resources? What is the tolerance in the selection criteria ±20%, ±10% or ±5%?
- Type of Review Expected - Will the expected estimate review be compatible with the objectives, or more stringent?
- Time Available for the Study - Will the time available for cost estimating permit handling the volume of data required at the lowest desirable level?
- Resources Available for the Study - Can the skilled estimators and data handlers be made available for a detailed study, or one at a higher level only?
- Availability of Data - At what level can a good match be made between product characteristics, schedule, and resource requirements of the estimated item and those of the data base?

The level of estimating detail is related to both the Work Breakdown Structure and the Resource Category Structure which form the definitional base for cost analysis and cost estimating.

V-1-a Work Breakdown Structure

The DoD WBS philosophy is indicated in the proposed Dod Directive and Military Standard "Work Dreakdown Structures for Defense Materiel Items." (Ref. V-1 and V-2). These documents recognize five WBS types:

- Summary WBS - The WBS as presented in the DoD Directive.
- Project Summary WBS - One or more Summary Work Breakdown Structures which reflect the content of the project.
- Project WBS - A detailing of the Project Summary Work Breakdown Structure.
- Contract Summary WBS - An extract of the portions of the Project Work Breakdown Structure involved in a particular procurement action.

- Contract WBS - A detailing of the Contract Summary Work Breakdown Structure accomplished by the contractor.

The last four WBSs are essentially a reorganization and/detailing of the Project Summary WBS, thus establishing a common (or uniform) technique for addressing an item of defense materiel.

For purposes of discussion here, these WBSs will be amplified to include two classes of elements (See Exhibit V-1).

- Prime Mission Product - Includes the principal item to be procured and, possibly, a major support element, such as the command and launch equipment of a missile system.
- Support Elements - Includes such Level 2 WBS elements as peculiar and common support equipment, spares, training and data.

This distinction essentially separates the high cost element from those which are normally factored (as a percent of the prime mission product) in the special study type of estimate because (1) the necessary inputs for making a detailed estimate are not normally available, (2) the elements are not normally overly sensitive to the objectives of the study and, (3) the costs involved are relatively small.

V-1-b Resource Category Structure

The second sector in structuring an estimate is the resource category (engineering, tooling, manufacturing direct labor and materials, overhead, fee, etc.). The RCS is seldom shown in summarizations of costs presented to management, yet it must be recognized in working reports for these reasons:

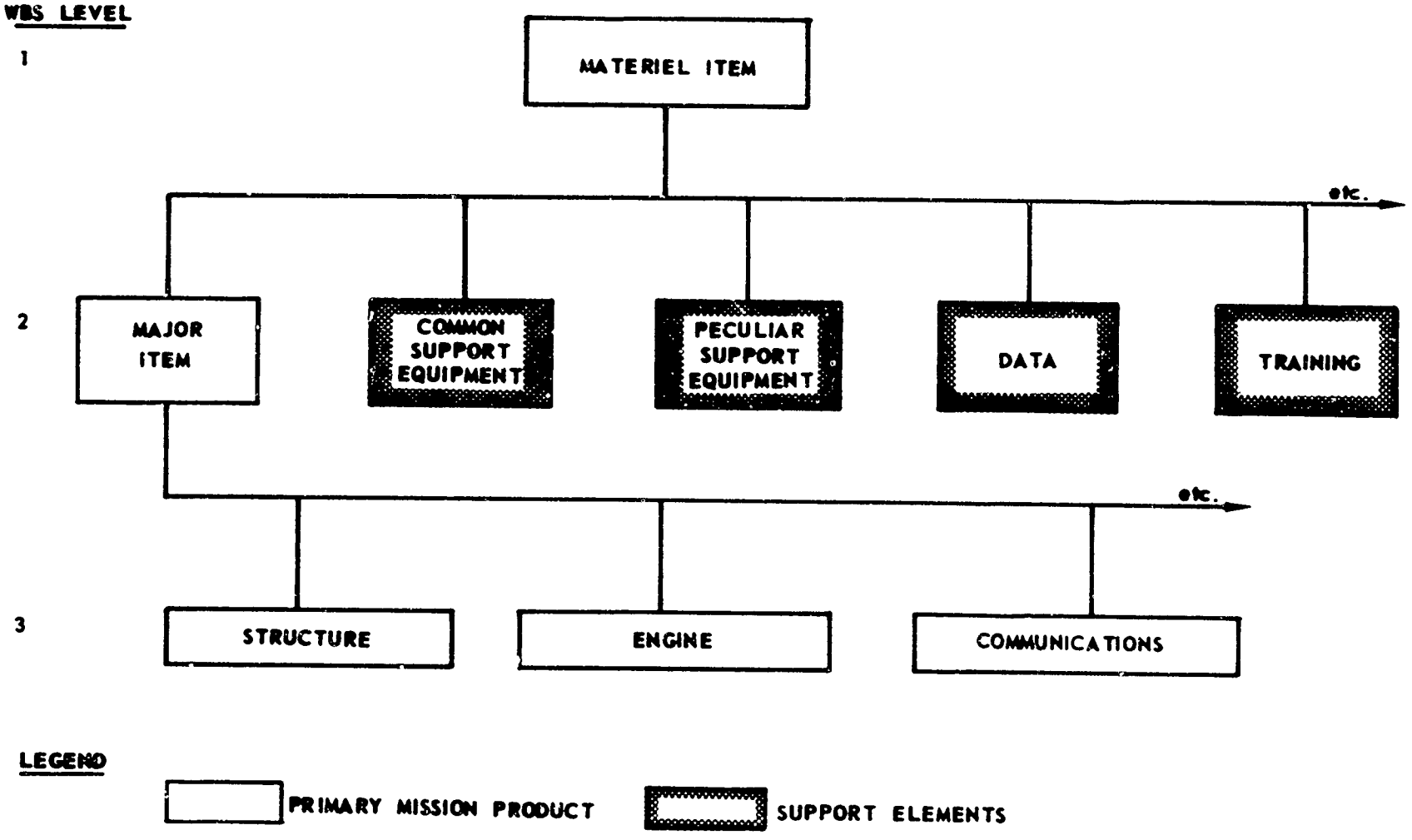
- Normally the peculiarities of a particular item and/or estimate are recognized at this level.
- The data from past programs are recorded at this level - on the Contract Pricing Proposal (DD 633 series of forms) (which accompanies most significant proposals and bids), and, in a limited number of programs, on the Cost Information Reports (DD-1558 series of forms).

It must be remembered that the important objective of a cost estimate is to reflect:

- Total cost
- The effect of decisions or variations upon total cost.

EXHIBIT V-1

EXTRACT OF TYPICAL MATERIEL ITEM WORK BREAKDOWN STRUCTURE



For the more gross parametric estimates or estimates where the combination (percent of cost in each category) of the categories is not expected to vary significantly, the resource category data can be loaded with the applicable overhead, fee,etc., and a cost/quantity relationship developed at the WBS element level.

In other estimates where the combination of resource categories can be expected to change significantly, over the quantity range or because of the particular objectives of the study, etc., the resource category costs may be treated as:

- Direct charges which are summed and then loaded with the applicable overhead, fee, etc.
- Direct charges which are loaded at the detail level then summed.

The former is used where the sensitivity of the cost to overhead rates and fee are to be examined, or to facilitate comparison with previous studies at a very detailed level. The latter is generally preferable from a data handling point of view, and for most estimates made in AMC, will provide the requisite level of accuracy.

V-2 COST ESTIMATING SCHEDULE

There are a number of basic steps or events in preparation of an estimate. The degree of formality associated with these steps or events will change depending upon such factors as the type of estimates, the time allowed for estimating, and the number of personnel or organization(s) involved.

In a major study which may involve a number of commodity commands, these would become major milestones or events. The following discussion addresses these steps in the context of such a major cost estimating task.

The schedule for such a cost estimating task has essentially eight major events:

1. Cost Estimating Task Assignment
2. Organization Meeting
3. Interim Report
4. Progress Meeting
5. Working Reports
6. Final Internal Review

7. Final Summary Report

8. Post Submission Evaluation

These events form a dynamic process that is initiated by the first event. The events are completed over time in the sequence shown; however, action on each of the second through seventh events would be initiated by the Cost Estimating Task Assignment. The final event is an analysis that should be performed to aid in future estimating tasks and would occur following completion of all other events.

V-2-a Cost Estimating Task Assignment

When the need for a cost estimate arises, the initiating action is a Cost Estimate Task Assignment in the form of a letter or memo or an oral request informing the estimating groups of the estimating task that is required. Exhibit V-2 presents an example of such a letter for a major procurement item. This letter addresses such points as the purpose of the task, the groups to be involved in the task, and the personnel to contact for further information. For major item estimating tasks, the task assignment may include attachments to better inform the cost estimating groups of the required task. When the task is received, the cost estimating group should begin its initial appraisal to determine their approach. The group members should familiarize themselves with the items to be estimated, determine what type of information is available for use in estimating the costs, and a proposed approach

This proposed approach should be explicit in all the details which are important to the cost estimators and should identify their proposed guidelines as follows:

- Extracted from the cost task assignment.
- Implied directly in the cost task assignment.
- Sought out or created by the cost estimator.
- Suggested deviations, from or clarification, of the cost task assignment.

At this time, the Cost Task Summary Sheet (See Exhibit IV-5) should be completed.

V-2-b Organization Meeting

After the groups have an initial appraisal, an organization meeting should be held, at which time the following should be established:

EXHIBIT V-2

TYPICAL COST ESTIMATE TASK ASSIGNMENT LETTER

DEPARTMENT OF THE ARMY
HEADQUARTERS UNITED STATES ARMY MATERIEL COMMAND
WASHINGTON, D.C. 20315

(Reference Symbol) (Date)

SUBJECT: Estimating of (Item) Production Costs

TO: Commanding General, U.S. Army . . . . . .

Commanding General, U.S. Army . . . . . .

1. Requirements are being placed upon this Headquarters which will necessitate estimating the cost of producing the (item). This effort is necessary in order to be able to respond to an (office) requirement to furnish cost data to support a system analysis study. Also, to support the FYDP needs for future budgetary and planning purposes, an updated hardware estimate based upon the latest technical specification packages and/or drawing releases is needed. Figures must be suitable for inclusion in the Army Materiel Plan (AMP).

2. In order to accomplish the above, the cost estimating groups already designated in each command, will be called upon to perform this estimate. To assure that one set of estimates can be compared with another, this basis for estimating, i.e., estimating methodology, uniform work breakdown structure, and cost category definitions, etc., will be established to maximum extent possible, at the first cost analysis conference to be held at (location) on (date). Ground rules, assumptions and constraints are included in the methodology paper attached hereto. The latest specification packages for each component will be mailed under separate cover by (office) to each appropriate command. Estimates are to be submitted to the (office) by the (date) for review and validation.

3. The attached methodology has been prepared with the assistance of (office) personnel who will assist in the implementation of the methodology. The commands should be prepared for visits from personnel from these offices accompanied by (command) personnel, during the estimating cycle.

4. For further information contact the following:

a. Technical (Name, Rank, Address, Phone Number)
b. Non-technical (Name, Rank, Address, Phone Number)

FOR THE COMMANDER

- Work Breakdown Structure (WBS) showing the complete breakout of all components and their relation to one another
- Estimating responsibility for each component.
- The WBS elements that require a functional cost breakout.
- The functional categories to be estimated and cost category definitions.
- WBS level at which to report non-recurring costs and costs which are not charged to the elements.
- Hierarchy of preference for estimating techniques.
- The production schedule(s) and/or quantities to consider.
- Ground rules, assumptions, and constraints.
- Schedule of milestones to be met in the estimating task.

These items are not necessariiy developed from scratch at the organization meeting, but the central position should be established such that groups have the same understanding of the estimating task and, thus, will be able to develop a uniform set of estimates that can be combined into an estimate for the task. For instance, a WBS should have been developed prior to the meeting, but the meeting should address the WBS to assure that complete coverage and responsibility for each WBS element has been established.

Each estimating group should be conducting a detailed search for applicable data and cost estimating relationships. Each group should then conduct a study to decide the estimating techniques which may be used for each element. The selection should reflect the hierarchy established at the organization meeting, the techniques that are feasible for each estimate, and the quality of data available. Techniques such as the following would be acceptable.

- Detailed engineering estimates - using complexity factors, detailed manloading, etc.
- Statistical methods, based on historical data - using CERs, learning curves and cost factors.
- Analogous components - using actual production costs on like items.

- Expert opinion - using the best available experts to fill areas where no other source is adequate.
- Contract data reviews - determining overhead, general and administrative expense, and profit rates.
- Price catalogs - determining costs of standard off-the-shelf items.

V-2-c Interim Report

The estimating technique chosen for each component and the reasons for choosing it should be detailed in an interim report. These reports from each estimating group should be reviewed to determine whether they are in consonance with the direction of the total effort. This Interim Report should follow the format of the Working Report presented in Section V-7. After the interim reports have been reviewed and accepted, the estimators will complete the actual task of estimating the costs. Appendix C presents an extract from such an interim report.

V-2-d Progress Meeting

At this meeting, the estimating groups should be able to present some tentative numbers and their estimating techniques. This meeting should serve to assure that all relevant costs are being estimated, that estimates from the various groups are consistent, and that acceptable techniques are being used.

After the progress meeting the estimators should correct any deficiencies in their methodology and then complete the cost estimate. Throughout the estimating task, the estimators should record all pertinent information and decision criteria used. The documentation should be such that an effective validation of the estimate could be performed by persons not involved in the actual estimating.

V-2-e Working Reports

The estimating groups should prepare Working Reports (See Section V-7) that present the full details of the estimates that have been developed. This Working Report will be part of the official documentation of the estimate and should include all data, relationships, assumptions, etc. that were used. It should also contain information such as estimate validation and tracking results, as well as the presentation of the estimates.

With the Working Reports for all estimates, the estimate coordinators can review the estimates to determine consistency and then assemble them to develop estimates for the total item. A Working Report can then be completed for the total item estimate.

V-2-f Final Internal Review

With the information furnished in a Working Report, a Final Review for each estimate can be conducted by tracing both logic and mathematics used in preparing the estimate. This review will be the last opportunity to make changes in the Working Report. Care should be taken to make sure that everything done in preparing the estimate is acceptable and completely documented in the Working Report. The format to be used for the Summary Report will be designated during this review.

V-2-g Summary Report

When satisfied that the estimate, as documented in the Working Report, is acceptable, a Summary Report following the format established in the Final Review should be completed. This report should present the major facets of the estimate. It also can serve as a justification document for presentation at higher headquarters. Exhibit III-9 presents a typical documention report outline.

V-2-h Post Submission Evaluation

To complete the estimating task, one event remains - an evaluation of the cost estimating effort and the recipient's comments. The primary purpose of the evaluation is to document areas where future cost estimates may be improved.

After the lead estimating group has presented the estimates to the requestor, the lead group will receive comments as to the impression and the problems encountered.

This lead estimating group should pass these comments to the estimating groups which should then prepare an analysis of implications of these comments along with their own evaluation of how the task could have been improved. This evaluation is one of the major, if not the major means for instilling professionalism in a cost analysis activity and for upgrading the capability of making cost estimates.

V-3 SOURCES OF COST INFORMATION

Outside the product characteristics of the item being costed, almost all cost information is founded on the records (estimates, cost reports, technical

reports, schedules, etc.) of current and past programs. The previous chapters have described in detail the characteristics and uses of this information for cost analysis and cost estimating. It must be emphasized that thorough and accurate documentation of previous estimates and analyses is a necessity for accurate cost estimating. This documentation, with the results of the past post submission evaluations, provides the basic ingredients for preparation of accurate and responsive cost estimates.

V-4 COST SENSITIVITY ANALYSIS

Cost estimates are normally single point estimates of total costs (or possibly summary cost/quantity relationships) which comprise a significant number of assumptions, ground rules, and conventions. Some of these assumptions or conventions can be traced to the initial task directive; others are generated during the conduct of the task to circumvent problems which could block completion of the task.

The cost sensitivity analysis addresses reasonable variations in those assumptions and ground rules and conventions and documents the cost effect of these variations. This analysis can highlight potential problem areas which could arise in the review or validation of the cost estimate, and it alerts the users to potential misinterpretations of the cost estimate.

V-5 VALIDATION OF ESTIMATE

The validation of an estimate occurs both at the working group level and at the recipient level. The validation of an estimate should build upon the validations of detailed data as indicated in the previous two chapters. If those procedures are properly accomplished, the validation of a specific cost estimate will consist of assuring that the cost estimate:

- Is a proper response to the ground rules set forth or implied in the study directive (as modified).
- Supports the analyses conducted in response to the study directive.

Although this validation primarily addressed the working report, the summary report must also be reviewed to assure that it properly reflects the working report(s).

At this level of validation there are eight basic validation points.

1. Arithmetical - This routine check should assure that the totals are supported by the details and that any reasonably well trained analyst can trace the derivation of the results.

2. Configuration - This validation point should assure that the cost estimate(s) reflects precisely the configuration specified or implied in the study directive and/or supporting analyses. This will require an in depth analysis of the product characteristics recorded and/or implied in the cost estimate documentation, in the study directives, and in any parallel analyses. This validation should be accomplished at the WBS element level.

3. Quantities - This validation point should assure that summary cost/quantity relationships are constructed on a valid basis and that the number of items (at the WBS element level) costed is correct.

4. Production Line Position - This validation point should assure that the most favorable and realistic prices are utilized in the study, particularly in view of pricing toward the lower end of the cost/quantity curves whenever justified by alternative demands from non-Army customers such as MIPR (Military Interdepartmental Procurement Request), direct sale to others such as commercial customers or to the Military Assistance Program.

5. Schedules - This validation point addresses two aspects:

   - Is the stated (or inferred) delivery schedule adequate to meet the requirements of the study, both in total and in time phasing?
   - Can the production schedule be met with the assumed industrial and government plant capacities?

6. Time Phasing of Costs - This validation point assures that the proper lead-lag relationships have been developed to place the cost estimate in the directed or stated time phasing (See Section IV-3).

7. Sensitivity - This validation point is oriented toward identifying soft spots in the cost estimate which have not been adequately treated. (See Section V-4). Implicit in all cost estimates are many assumptions and/or ground rules which, if altered, could have a significant effect on cost. The recipient of the cost estimate has every right to expect to be warned of these implications.

8. Reasonableness - This validation point addresses the overall approach used by the cost estimator, his logic used in extending the available data base, his construction of CERs and his

interpretation of the task assignment. It is essentially subjective, hence, should be approached cautiously.

V-6 COST ESTIMATE CHANGE REPORTS

The purpose of cost estimate reports is to document variances in cost estimates made at various points in the life of a system or of an item; i.e., how and why cost estimates have changed over time. The term "cost estimates" is used here in its broadest context to include cost/quantity positions negotiated with or directed by higher authority. Two such reports are:

- Cost Estimate Tracking Reports -These reports document the full history of cost estimates. The AMC Cost Estimate Tracking System currently under development will identify these reports.
- Cost Estimate Change Summary -This summary is designed for management consumption, hence, addresses only the change from the previous position at a summary level.

The purpose of the cost change summary report is to provide the reviewer with a quick check on the most recent history of the estimate and to provide a ready reference source for more extensive research into the estimate history. Exhibit V-3 presents such a Cost Estimate Change Summary Sheet.

To provide a quick identification of the changes in estimates, two broad categories have been established. These are:

- Scope Changes - Those which result from overt actions taken by the Army or directed by higher authority, such as changes in the performance characteristics of a system, quantities, schedules, etc.
- Price Changes - Those which result from circumstances beyond the control of the Army. For example, the reestimation of an item or system in view of dollar changes in the nations economy, a previous conservative evaluation of the technical challenge, or directed changes by higher authority without change in scope.

Explanations of changes should be indicated by an entry in the column headed "Change Explanation" on the Cost Estimate Change Summary. The changes may be classified according to the following system:

EXHIBIT V-3

COST ESTIMATE CHANGE SUMMARY SHEET

COST ESTIMATE CHANGE SUMMARY SHEET								
Item Estimated:					Date:			
Source Documentation*	Prior Estimates:							
	Current Estimates:							
Previous Change Summary*								
	Estimating Command		Origin of Request		Type of Estimate		WBS Level	
Prior								
Current								
	Estimates				Change		Change Explanation	
	Prior		Current					
FY	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
Prior Years								
Total								
Notes:**								

*In bibliographic style, use reverse if necessary.

**Use reverse if necessary

Scope Changes

A-1 Changes in the requirements or performance characteristics of a system such as speed, payload, range, accuracy, mean time to failure, maintenance intervals, etc.

A-2 Changes in the quantity to be produced

A-3 Changes in the development or production time schedule

A-4 Changes in the scope of a system other than those covered by codes A-1, A-2, A-3. When A-4 is used, the nature of the change must be fully explained under remarks.

Price Changes

B-1 Dollar changes in the nation's economy such as changes in general and specific price levels. Included in this category are changes resulting from inflation, labor rates and cost of materials.

B-2 Re-interpretation of engineering or technical specifications regarding performance requirements of the system.

B-3 Non-technical problems, such as strikes, floods, acts of God, excessive shortages of manpower or material and changes not covered by B-1, or B-2. When this category is used, each entry should be fully explained under remarks.

B-4 Directed changes such as budget costs which may infer a scope change, but do not directly state the specific change.

At the conclusion of each cost estimating task, the estimators should complete the format as a part of the working report.

V-7 ESTIMATE DOCUMENTATION AND PRESENTATION

The documentation and presentation of an estimate is the culmination of an extensive effort to produce an approximation of future costs. It is important that documentation and presentation be accomplished in a professional manner to increase the credibility of the estimate, to facilitate its review and utilization and to create a data base for future use. To this end the following two reports are important.

V-7-a Working Report

The approach presented herein generally follows that presented in Chapters III and IV, to provide continuity and uniformity without being overly restrictive.

EXHIBIT V-4
COST ESTIMATE WORKING REPORT OUTLINE

- Cover Page
  - Title
  - Prepared for _____
  - Prepared by _____
  - Participating Organizations
  - Approving Authority (Name, rank and/or title and signature)
  - Date of Approval
  - Key Analysts
- Cost Task Summary Sheet (See Exhibit IV-5)
- Cost Estimate
- Cost Estimate Change Summary
- Cost Estimate Quality Control Checklist (See Exhibits IV-7)
- Contents
- Introduction
  - Purpose of Estimate
  - History of Estimate
  - Brief Description of Items or Systems (Including developmental status)
- Study Ground Rules
- Constraints
- Assumptions
- Work Breakdown Structure
- Organizational Responsibilities
- Information Summaries
  - Product Characteristics
    - Tabular (See Exhibit III-11)
    - Graphic (Comparisons of data base with products being estimated)
  - Schedule (Tabular or graphic)
  - Resource Expenditure (Similar to Exhibit III-11)
- Reference Unit Costs
- Data Base Items (Brief description)
- Cost Estimating Relationships Used (With constants)
- Cost Sensitivity Analysis
- Validation Report
- Cost Escalation Implications
- Results (Cost estimate details)
- Conclusions
  - In Response to Task Assignment
  - Relative to Cost Analysis and/or Cost Estimating
- Appendixes
  - A – Study Directives, Instructions, and Correspondence (A bibliographic list by date of receipt or date of origin for outgoing documents followed by copies of study.)
  - B – Cost Estimate Schedule
  - C – Bibliographic List of Cost Information Survey
  - D – Bibliographic List of Interim Reports, Working Reports and Ancillary Reports.
  - E – Cost Estimate Change Detail.
  - F – Summary Report (Annotated as to Working Report source for each item of cost information.)

V-7, Estimate Documentation and Presentation

Exhibit V-4 presents an outline of the Cost Estimate Working Report. It is intended that this report be the focal point for any analysis of the cost estimate, since it should be complete and comprehensive. It is not intended, however, that ancillary studies be repeated in the working report.

The ancillary reports, like the technical (CER) working report (see Section IV-4) may be incorporated by reference. This reference should clearly indicate (by page and paragraph) the significant portions of the incorporated report.

V-8 SUMMARY REPORT

The Cost Estimate Summary Report is prepared by the cost estimating team leader in concert with the team members. It summarizes the cost estimates presented in the Working Reports for top management consumption, hence, should be relatively short and to the point.

The report, above all, should cover the significant points of the estimate including a clear presentation of the results of the sensitivity analysis. The soft spots in the estimate should be clearly identified as to the reason for their presence together with their cost implications. Exhibit V-5 presents an outline of the Summary Cost Estimate Report.

EXHIBIT V-5

SUMMARY COST ESTIMATE REPORT OUTLINE

Cover Page

- Name of Study
- Prepared for _____
- Prepared by _____
- Participating Organizations
- Approving Authority (Name, rank, and/or title and signature)
- Date of Approval

Contents

Introduction (1 to 3 pages)

- Purpose of the Study
- Key Ground Rules
- Critical Constraints
- Key Assumptions

Work Breakdown Structure

Items and Conditions Included

Methodology (1 to 2 pages)

Presentation of Study Results (2 to 4 pages)

Conclusions (1 to 2 pages)

Appendix A: Cost Estimate Change Summary

Appendix B: Study Directives (In bibliographic style)

Appendix C: Working Reports (In bibliographic style)

Note: The page count presented here is for guidance only.

Chapter VI

ORGANIZATIONAL IMPLICATIONS

The Administrative-Decision Making and Resource Administration Functions, with some of their attendant organizational implications, were presented in Chapter II, "Army Materiel Command Estimating Framework." This chapter presents a discussion of some organizational relationships with higher military and civilian authority and with the subordinate commands to introduce the cost analyst and cost estimator to the complex organization within which the cost analysis function exists. It should be remembered that cost analysis, as related to the organizational function, includes both cost analysis and cost estimating processes.

This discussion presumes that the reader has a general understanding of the organization, mission and functions of Headquarters, AMC, such as is presented in "Organization, Mission, and Function of Headquarters, AMC," (Ref. VI-1). It also assumes that the reader has been introduced to organization theory. Since organizational theory is not a well-defined discipline, a short discussion of basic theory and terminology, as used herein, is presented in Appendix D.

VI-1 COST ANALYSIS RESPONSIBILITIES

Cost analysis activities have been established in OSD in the Office of the Assistant Secretary of Defense (Systems Analysis) and in the Office of the Comptroller of the Army in OCSA.

In accordance with its assigned mission, to "Provide... technical and professional guidance required for support of DA materiel..." (Ref. VI-1) AMC Headquarters is required to respond to an increasing number of requests for inputs to special studies being performed at the Office of the Chief of Staff, U.S. Army (OCSA), Office of the Secretary of the Army (OSA), and Office of the Secretary of Defense (OSD) levels in addition to accomplishing more special studies at the AMC level.

In responding to this increasing workload the cost analysis function has been authorized by OSD in the "Army-Wide Cost Analysis Activity" Program Change Decision (Ref. VI-2, see extract in Section 1-2). This decision authorized the establishment of a focal point for all cost analysis activities in the Comptroller staff and indicated that resources to accomplish the authorized effort would be provided. Based upon the authority contained in the decision, a Cost Analysis Branch has been established at AMC Headquarters with the mission and functions as described in the following proposed change to AMCR 10-2:

SYSTEMS AND COST ANALYSIS DIVISION

"MISSION

a. Perform, direct, supervise, coordinate and evaluate systems analysis-cost effectiveness studies prepared by or for AMC on Army materiel systems. Provide the AMC focal point for such studies and staff supervision of the AMC Army Materiel Systems Analysis Center (AMSAC) activities.

b. Est lish general policy, direction and guidance for the systems analysis within AMC and the use of technical techniques and administration of Systems Analysis/Cost-Effectiveness (SA/CE) studies related thereto.

c. Establish and exercise staff and technical supervision over AMC cost analysis activities to provide over-all cost analysis for research, development, acquisition and production, maintenance and logistics and operations of weapon systems/items, activities and forces.

d. Provide the AMC central focal point for cost analysis activities, studies and submissions; to include cost estimates, factors and cost data and information, and the techniques and methods for their establishment and accumulation, as related to the AMC mission.

e. Perform special systems analysis/cost-effectiveness and cost analysis studies as may be required.

FUNCTIONS

1. SYSTEMS ANALYSIS BRANCH

.
.
.

2. COST ANALYSIS BRANCH

a. Perform the HQ,AMC staff supervision function for Cost Analysis studies and activities within the AMC.

b. Establish, direct and supervise the AMC Cost Analysis Program and the AMC system for cost collecting, estimating, tracking, evaluation and reporting to include the development and use of cost estimating relationships (CER).

c. Establish, direct, and coordinate policies, standards, methodology, techniques and procedures for the application of cost analysis in AMC, including its use in planning, programing and budgeting; inputs to SA/CE and special materiel studies; and the conduct of specific costing studies and their analysis.

d. Establish, monitor and coordinate a centralized, integrated data system for use at all levels for cost estimating.

e. Prepare and/or review cost estimates and cost studies on resource requirements for military systems materiel and programs.

f. Provide HQ,AMC cost analysis on program/budget estimates prepared for submission to higher authority.

g. Provide cost analysis support for project managers assigned to and located at HQ,AMC, and to HQ AMC Directors.

h. Perform cost analysis research, and develop cost analysis methodology and techniques for standardization and application within the Army Materiel Command.

i. Monitor and control and assignment of cost analysis studies and/or input to studies directed by HQ USAMC and higher authority.

j. Develop and supervise a U.S. Army Materiel Command Cost Analysis Career Development Program.

k. Maintain liaison with DA, higher authority and industry on Cost Analysis activities.

l. Develop and maintain a cost data base, including cost estimating relationships, covering all major systems managed by AMC.

m. Perform HQ,AMC staff responsibility and centralized direction for the DOD/DA Life Cycle Costing Program.

n. Perform special cost studies and cost estimates as required by higher authority, the Command Group of AMC, or the internal operations of AMC.

o. Review and evaluate PM^2Ps and CM^2Ps for cost analysis/cost estimating implications and the entry of cost information contained in PM^2Ps and CM^2Ps into the AMC Cost Data Base.

p. Develop and maintain the C/DP capability, and represent the C/DP on all matters relating to Cost Analysis activities within AMC: with other Army commands and agencies; with other military services and government agencies; and with contractors and private concerns.

q. Prepare and publish the AMC Cost Analysis Monthly Exchange (CAME).

r. Develop cost factors as appropriate, to include factors and formats for special materiel studies, logistic or support cost studies, or for contingency or logistics operations or operational plans.

s. Provide for the evaluation and recommendation to the C/DP for clearance and release of all cost data for use in cost analysis or costing studies, in presentations or official correspondence."

Commodity commands' functions in cost analysis are being established to reflect the Cost Analysis Branch, AMC, statement of functions. It is apparent from a study of the above statements and references that the cost analysis function has complex organizational ramifications not only laterally, but vertically as well. It is appropriate, therefore, that a brief review be made of applicable basic management principles and organizational theory which apply so that the analyst may more fully understand the implications of his work.

VI-2 BASIC ORGANIZATIONAL THEORY

There are three basic organizational forms:

- Line
- Line & Staff
- Functional

The following sections address these forms in the context of AMC relationships.

VI-2-a Line and Line & Staff

The relationship between a superior and subordinates over whom the superior exercises direct control is referred to as "an authority relationship in direct line." In those cases where AMC's Cost Analysis Branch directs and supervises the AMC Cost Analysis Program, a superior/subordinate line relationship exists. For example, the verbs such as direct, assign, establish, and control as used in functions b,c,d, and i, indicate line authority.

A staff organization seldom exists in a pure sense. Almost all staff groups have a line responsibility as well as that of staff (for their own management, if for no other reason), hence, the classification "Line & Staff".

In those cases where the Cost Analysis Branch supports another office, it is in a staff relationship. For example, the verbs prepare, perform, review, and provide as used in functions e,f,g,h,j,and s, indicate a staff relationship. Thus the Headquarters, AMC Cost Analysis Branch is clearly a "Line & Staff" organization.

VI-2-b Functional

This organization form is a variation of the line and staff form where an organization receives direction from more than one source either on different functions or on the same function for different purposes. For example, the Cost Information Report staff responsibility flow depicts the functional organization. Exhibit VI-1 presents a typical line and staff organization. The left column presents the offices in the line of command between Secretary of Defense (OSD) and the Commanding General, AMC (HQ, AMC). The next three columns present the three key staff offices which are more significant to the Cost Analysis Function. The titles for these staff lines are taken from the OSD titles, as organizations which are nearer the operating levels tend to divide some of these functions into a number of co-equal organizations to facilitate management.

Overlaid on this matrix is the flow of staff responsibility for the Cost Information Reports prescribed in Reference VI-3. These reports are prescribed by the Assistant Secretary of Defense, Comptroller in OSD and are handled by the Financial Manager in OSA and the Comptroller of the Army at OCSA, but have been placed in the Installations and Logistics Staff at HQ, AMC for implementation.

It should be emphasized that this is a presentation of staff (or technical supervision) relationships only. Any matters that are directive in nature pass through the line organization, tacitly if not actually.

Another form of functional organization which has become increasingly important, but is not shown in Exhibit VI-1 is the Project Managers, chartered in accordance with AR-70-17, (Ref. VI-4). These organizations hold a position somewhat analogous to the line offices in that the Project Manager's support is drawn from all affected staff organizations and may have specialists from each of the staff organizations assigned to the Project Manager's organization. Since the project offices are line and staff in nature, but do not fall within the normal staff responsibility flow, they are functional in nature.

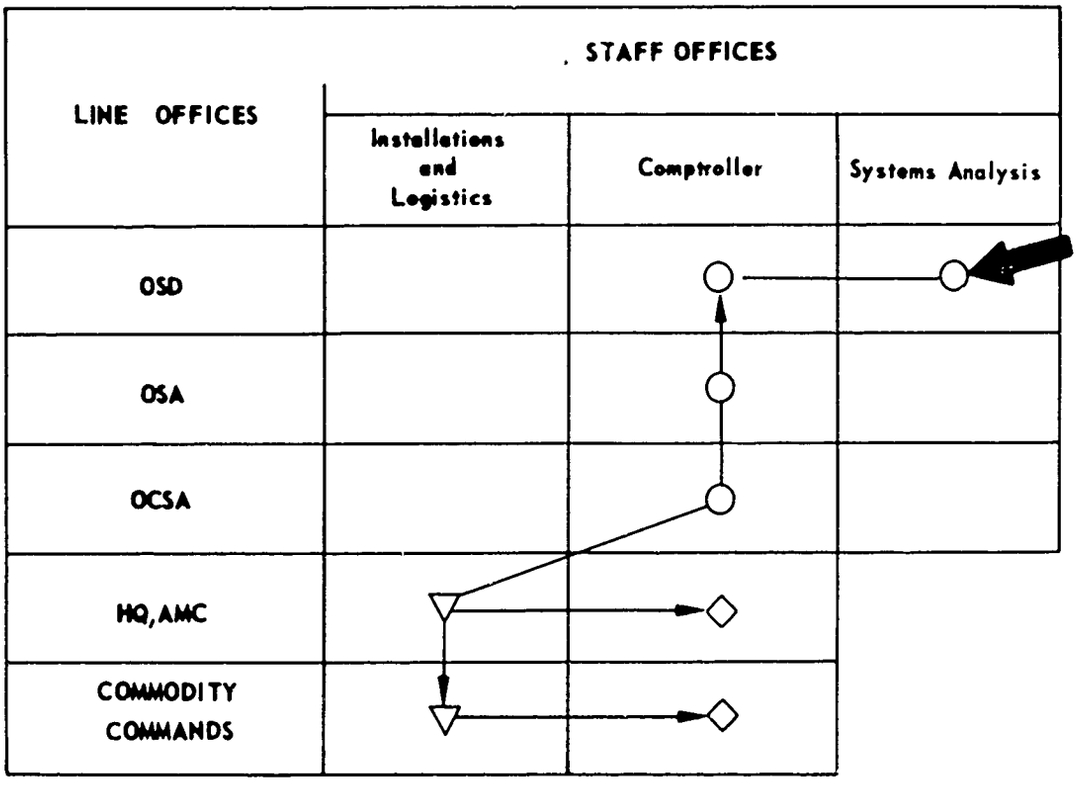
VI-3 AMC STAFF INTERFACES

The staff interfaces which exist for the Cost Analysis Branch at Headquarters, AMC is indicative of the relationships that can be expected to exist at the Subordinate Command level. Variations can be expected to exist because of the local conditions; hence, care must be exercised in drawing specific analogues at the subordinate command level.

EXHIBIT VI-1

STAFF RESPONSIBILITY FLOW

COST INFORMATION REPORTS



▽ IMPLEMENTATION AND DATA COLLECTION

◇ ANALYSIS

○ FULL STAFF RESPONSIBILITY

VI-3-a Cost Analysis

The function of cost analysis exists in some form in almost all staff offices to accomplish the following:

- To estimate the requirements for funds to carry out their assigned missions and tasks.
- To determine the progress in completing the assigned mission and task.

These tasks are essential to any managerial function and the responsibility for their performance cannot be delegated.

Parallel to this cost analysis function is that assigned to the AMC Comptroller/Director of Programs. The Comptroller function has a broader mission of establishing "...policies, standards, methodology, techniques and procedures for application of cost analysis in AMC..." (function c), "review and evaluation" (functions o and s) and the "Perform special studies" (functions e, i, and n).

Thus, a delicate interface exists at equal staff levels between the managers who have the detailed Resource Administration responsibilities and the Cost Analysis Branch which has the technical responsibility for techniques and methods, and a strong role in the Administrative-Decision Making area.

VI-3-b Life Cycle Cost

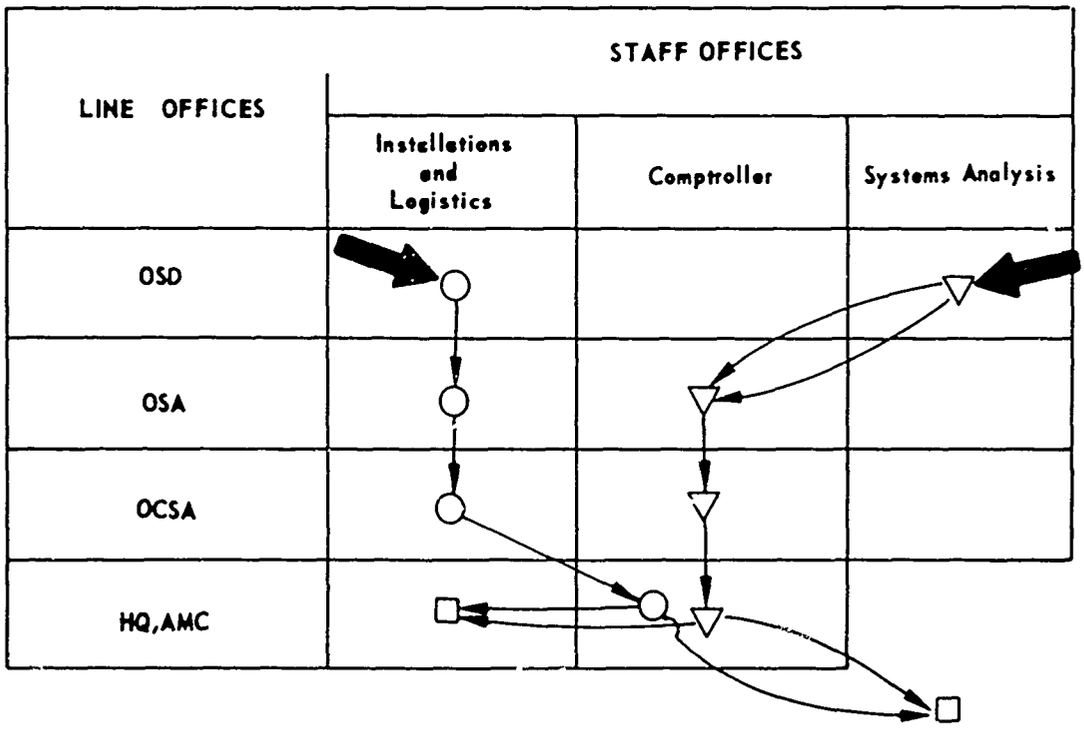
The staff responsibility flow for the two forms of Life Cycle Cost currently being addressed in the Department of Defense is presented in Exhibit VI-2. These two forms are:

- Equipment - This effort addresses equipment items such as:
  - M113 EI Armored Full-Tracked Personnel Carrier
  - Truck (cargo $2\frac{1}{2}$ Ton M-35)
  - ARC-84 VHF Transceiver
  - ARC-52 UHF Transceiver
  - Re-usable Metal Containers for Jet Engines
  - PRC-25-Man Pack Radio
  - VRC-12-Vehicular Radio
  - GRC-50-Combat Area Microwave Transmitter/Receiver
  - Commercial Engine for the Army 19 Ton Truck

EXHIBIT VI-2

STAFF RESPONSIBILITY FLOW

LIFE CYCLE COST



▽ MAJOR SYSTEMS

○ EQUIPMENT

□ TO OTHER STAFF OFFICES AND COMMANDS FOR IMPLEMENTATION

- Major Systems - This effort addresses such major systems as:
  - Sentinel
  - Main Battle Tank (MBT-70)
  - Cayuse
  - Chinnok
  - Iroquois
  - Flying Cranes
  - Mallard
  - SAM-D

The Equipment Life Cycle Cost effort is an Installations and Logistics staff responsibility above the AMC level. One result of this staff influence is the emphasis being placed upon use of Life Cycle Cost in contracting and source selection.

The Major Systems Life Cycle Cost effort originates in the Systems Analysis staff at OSD and is handled in the Comptroller staff within the Army. One result of this staff responsibility flow is the emphasis being placed upon the use of Life Cycle Cost in special studies for Administrative-Decision Making.

Both of these efforts are brought together at Headquarters, AMC for development and implementation.

This particular staffing pattern places the Cost Analysis Branch in a position of coordinating two efforts which use similar terms but have been defined by two different staff organizations.

VI-3-c Commodity Management Master Plans (CM^2P)

Another type of staff responsibility flow, illustrated in Exhibit VI-3 by the CM^2P flow, is essentially an up then down flow. The CM^2P is originated by the commodity manager in response to requirements established by or inferred in the JSOP. The CM^2P follows the Installations and Logistics staff responsibility flow, with an "...evaluation and recommendation... for clearance and release.." (function s) being accomplished by the AMC Cost Analysis Branch.

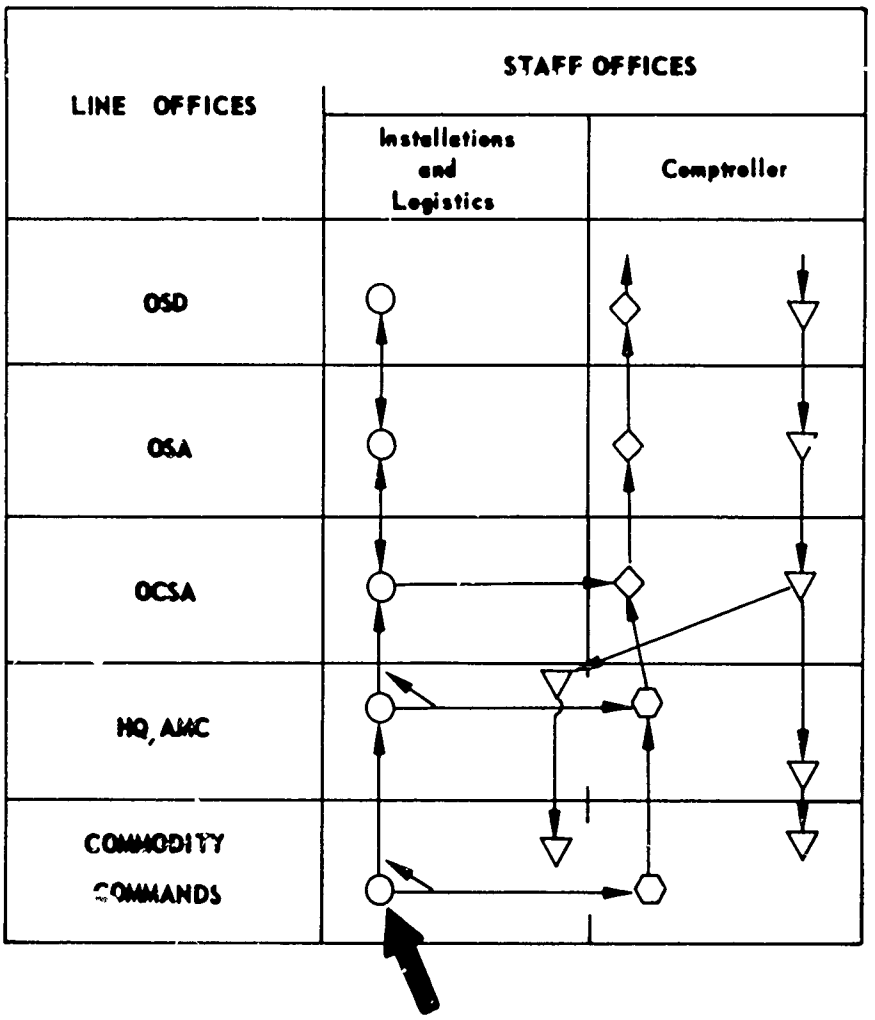
A similar flow exists for the Project Management Master Plan (PM^2P).

On the down flow side, analogous information in the form of Obligation Authority passes through the Office of the Comptroller and Director of Programs providing an opportunity to match funds requested with the obligation authority granted on an AMC-wide basis.

EXHIBIT VI-3

STAFF RESPONSIBILITY FLOW

COMMODITY MANAGEMENT MASTER PLAN



○ PRODUCT CHARACTERISTICS, QUANTITIES AND COST

◇ PROGRAMMING AND BUDGETING

▽ OBLIGATION

⬡ REVIEW AND EVALUATION

VI-4 CONCLUSION RELATIVE TO THE COST ANALYSIS FUNCTION ROLE IN AMC

The Cost Analysis Branch function statement addresses cost analysis in its broadest application - the capability to complete definitive cost analyses and cost estimates in each and every sector of AMC activity as indicated in functions c, f, h, and y. This multi-disciplinary capability is demanding and difficult. There does not now exist in the current literature a single comprehensive work which definitively addresses such a complex subject; hence, the cost analysis function must develop that literature concurrent with keeping abreast of its assigned special studies, analyses,and estimates.

The cost analyst/cost estimator should be aware of these organizational implications for the following reasons:

- They will serve to indicate the kind of response to cost tasks each organizational element is anticipating.
- They will give an indication of how the cost task requirements originate and how the results are used.
- They will indicate sources of data and support.

The organization structure will have an effect upon the cost analyses and estimates performed, particularly as related to the presentation of results and the review which the results will receive.

Finally, the cost analyst or cost estimator should be aware of the broader roles of the cost analysis function when conducting an analysis or an estimate, as there may be many useful outputs of the study which could support these roles.

APPENDIXES

Appendix A

LEARNING CURVES

Appendix A

Learning Curves

Learning curves express the variation in cost over a range of production quantities. This appendix presents a brief discussion on learning curves, indicates where to obtain further information, and presents an example of the learning curve derivation illustrated in Exhibit III-7.

The learning curve theory was originally developed by T. P. Wright and used in estimating the direct-labor cost of aircraft production. The use of this technique has been extended to costs other than direct labor and to other products.

In analyzing factors that affect the cost of airframes, T. P. Wright was the first to formulate into mathematical theory the principle of decreasing direct-labor cost as the number of units produced is increased. Wright described the relationship between average cost and cumulative number of units produced as follows:

$$\overline{C} = K_{v_2} X^k$$

Where:

$\overline{C}$ = Cumulative average cost
X = Production unit
K_{v_2} = Cost at reference unit (Unit one)
k = Learning curve slope factor

Essentially this formula states that as the quantity doubles, the average cost decreases by a given percent (referred to as the slope of the learning curve). The learning curve slope factor is always a negative exponent as shown below for representative slopes:

Learning Curve Slope Factors

Slope	Factor
65%	-.62150
70	-.51457
75	-.41504
80	-.32193
85	-.23446
90	-.15201
95	-.07401

J. R. Crawford later defined a learning curve in terms of the unit cost versus the production unit. The equation proposed by Crawford is as follows:

$$C = K_{v2} X^{k}$$

Where:

C = Unit cost of production unit X.
X = Production unit.
K_{v2} = Cost at reference unit (Unit one).
k = Learning curve slope factor.

This is the most commonly used learning curve and is sometimes referred to as the Modified-Wright learning curve. Tables of this learning curve for 67% to 99% slopes are presented in The Experience Curve Tables, Volumes I and II (Reference A-1).

Another analysis of the learning curve function was developed by the Stanford Research Institute. Stanford described the relationship between the unit cost and cumulative units as follows:

$$C = K_{v_2} (X + B)^{-.5}$$

Where:

C = Unit cost of production unit X.
X = Production unit.
K_{v2} = Cost at reference unit (Unit one).
B = Learning curve shape factor.

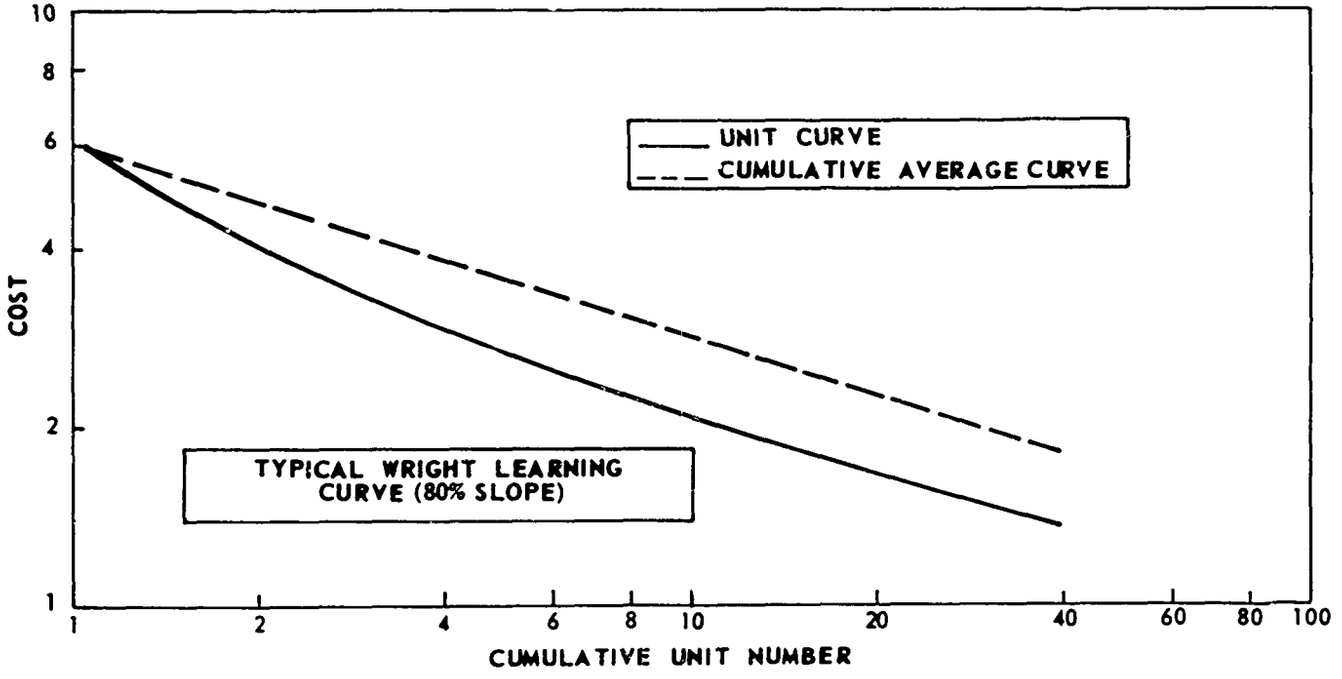
The parameter B has no specific meaning but it determines the shape of the learning curve and has been related to variables such as time required to attain a peak delivery rate.

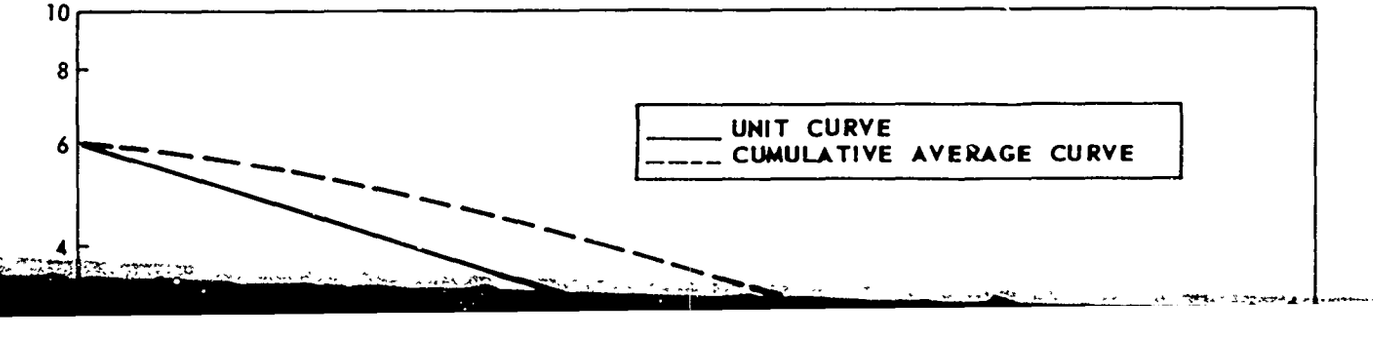
Exhibit A-2 shows graphic presentations of the three types of learning curves mentioned. It is seen that Wright defines the learning curve in terms of the cumulative average curve being linear on logarithmic grids, whereas Crawford defines the learning curve in terms of the unit curve being linear on logarithmic grids. The asymptote of the Stanford progress curve is a 70.7% Modified-Wright learning curve and the shape of the Stanford curve would vary with the value of B.

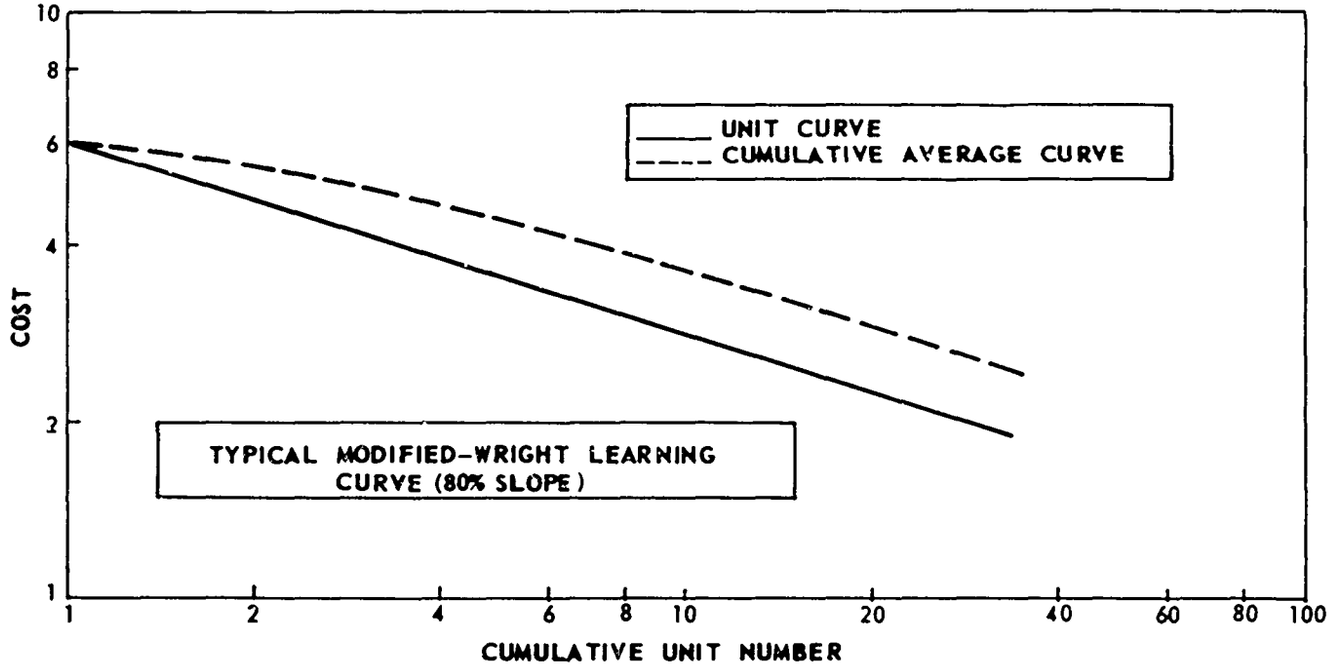
It should be noted that the essential difference between these curve theories deals with the shape of the curve in the early production of quantities.

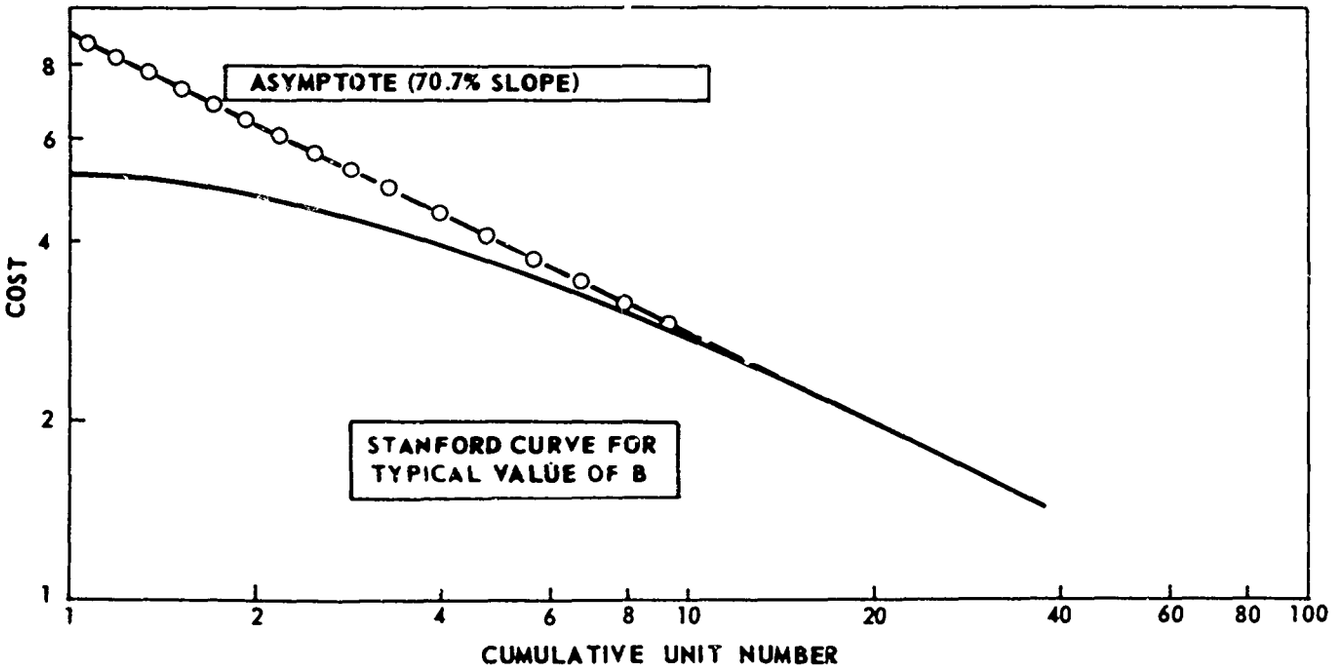
EXHIBIT A-1

TYPES OF LEARNING CURVES






UNIT CURVE
CUMULATIVE AVERAGE CURVE
TYPICAL MODIFIED-WRIGHT LEARNING CURVE (80% SLOPE)
COST
CUMULATIVE UNIT NUMBER
10
8
6
4
2
1
1
2
4
6
8
10
20
40
60
80
100


ASYMPTOTE (70.7% SLOPE)
STANFORD CURVE FOR TYPICAL VALUE OF B
COST
CUMULATIVE UNIT NUMBER
8
6
4
2
1
1
2
4
6
8
10
20
40
60
80
100

B

The example presented in Exhibit III-7 illustrates the derivation of a Modified-Wright learning curve using lot data. When using lot data in the calculation of the learning curve, the entire lot is represented as one unit entry. The unit chosen to represent the lot is the unit which has a cost equal to the average unit cost of the lot. Tables for Approximation of Mid-Points for Exponential Regression (TAMPER) (Reference III-9) refers to this unit as the algebraic lot mid-point and presents tables for obtaining it as a function of lot size, first unit in lot, and learning curve slope.

In the example, the units in each lot and the average cost per unit for each lot were reported data. Judgment was used to determine approximately what the learning curve slope should be. Iterative approximations were made for the learning curve slope, and the TAMPER tables were used to obtain the algebraic lot midpoints for each slope. The average cost for each lot was plotted at these midpoints on log-log paper. Log-linear curves were fitted to these plots using the regression analysis technique presented in Appendix B for the respective slopes, and the learning curve that gave the best fit was used to obtain the cost of the reference unit. The learning curve derived in the example has an 87% slope. On Exhibit III-7 it is seen that the reference unit cost (the equivalent cost at unit one) is $2,300.

The last four lots give a relatively good fit to the learning curve while the average cost for the first lot (the unit cost of the algebraic midpoint) is $2,700 above the cost on the learning curve at the algebraic midpoint. This indicates that the first lot data includes some non-variable costs and that the average non-variable cost per unit in this lot is $2,700. This yields a total non-variable cost of $54,000 (20 units x $2,700).

For an introduction to learning curves including history, theory, and application, the reader is referred to Alpha & Omega and the Experience Curve (Reference A- and to Cost-Quantity Relationships in The Aircraft Industry (Reference A-3).

Appendix B

DERIVATION OF COST ESTIMATING RELATIONSHIPS

Appendix B

Derivation of Cost Estimating Relationships

A cost estimating relationship is an expression which relates the cost of an item at some specific quantity to that item's product characteristics. This appendix serves to describe the steps in the derivation of a CER that follow after the cost data have been reduced to reference cost. (K_{n_V}, K_{V_1}, K_{V_2}, and K)*. Referring to the typical CER derivation flow presented in Exhibit I-5, the subject examined here is the last step shown in that exhibit. The statistical method for derivation of CERs (introduced in Chapter III) is discussed and details of the derivation of the CER shown in Exhibit III-8 are presented.

When the cost data have been reduced to the reference costs, the next step in the analysis is the selection of the product characteristics to use in the CERs. This step requires that the cost analyst have a firm knowledge of the product and the importance of the product characteristics, since determination of the relative affect of each product characteristic on the product cost demands expert judgment.

The most obvious consideration in selecting product characteristics is the sensitivity of cost to changes in the values of the various characteristics. Other considerations may be expressed by the following questions:

- Does the purpose for which estimates are to be used indicate any characteristics which should receive special emphasis?
- Can values of the characteristics be obtained for the item to be estimated? (This is of primary concern in estimates to be made early in the development cycle.)
- Are there state-of-the-art changes in the item to be estimated that will cause the relationship between characteristic and cost to be different than in the past? (For instance, the relationship between weight and cost for electronics equipment changed considerably when transistors replaced tubes.)

In evaluating the product characteristics, the sensitivity of cost to individual characteristics is generally observed first in order to determine trends. After the trends are determined, relationships between cost and combinations of characteristics are observed. Multi-variable relationships of different orders (characteristics squared, cubed, etc.) and forms (exponential, logarithmic, etc.) might be constructed with an individual coefficient for each

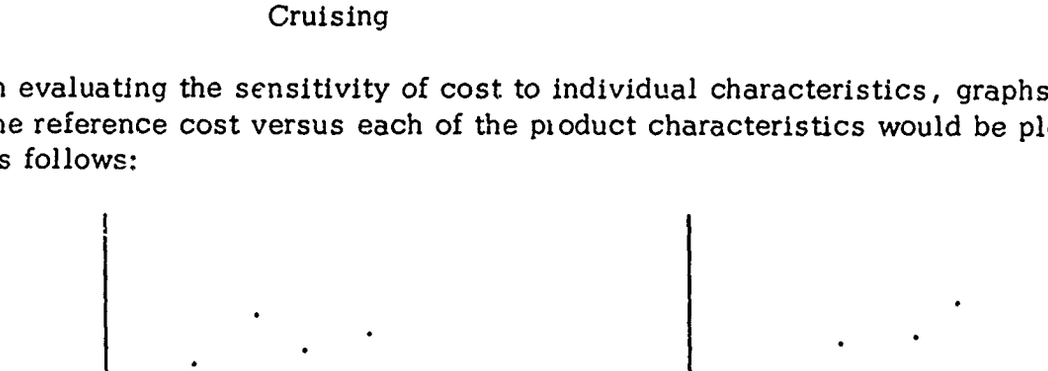
*Note: K_{n_V}, K_{V_1}, K_{V_2}, and K, are described in Section I-2-e, Construction of a Cost Estimating Relationship.

characteristic that is used as an independent variable, or the characteristics may be combined into an index such as density in Exhibit III-8. Although density is a commonly used term, it is not necessary that the index have such significant meaning; rather, it can be any combination of characteristics.

Airframe CERs have been developed considering such product characteristics as:

- Gross take-off weight (including engines, avionics, fuel, and payload).
- Weight empty (payload and fuel not included).
- Airframe weight (as defined on page 45 of Reference III-7).
- Volume (using the external envelope of the aircraft).
- Speed:
  - Maximum at sea level
  - Maximum at optimum altitude
  - Cruise
- Wing Loading
- Maximum range or radius
- Altitude:
  - Maximum
  - Cruising

In evaluating the sensitivity of cost to individual characteristics, graphs of the reference cost versus each of the product characteristics would be plotted as follows:



After observing the cost variation with individual characteristics, logical combinations of characteristics will be selected and the variation of cost with these combinations observed. By combining the characteristics into

a single index (such as the ratio of weight to volume used in Exhibit III-8), a graph can be plotted showing cost vs. the index.

The final step in developing CERs is to define curves fitted to the plots of scatter points. The initial fits are normally made graphically with the final fit being made mathematically. Regression analysis is a common method for mathematically fitting a curve to the data.

To introduce regression analysis, consider the case of two variables such as those used in Exhibit III-8. If we plot the values of the cost variable (X) versus the values of the product characteristic variable (Y), we will have a presentation of the sample information in the form of a scatter-diagram. This scatter of points should indicate the form of the regression equation that should be developed to express the relationship between X and Y.

The most common statistical method used to determine regression curves is that of least squares. The property of a least-squares regression line is that the sum of the squares of the deviations around it is less than the sum of the squared deviations around any other line through the scatter of points.

In Exhibit III-8, the method of least squares is used to develop a linear regression line for estimating X (cost per pound at the referenced unit) when Y (density) is known. Thus, the equation for the line will be of the form $X = a + bY$ where a is the X intercept and b is the slope of the line. To meet the properties of a least squares line, the following equations can be derived for obtaining the values of the constants a and b:

$$b = \frac{\Sigma YY - \frac{\Sigma Y \Sigma X}{n}}{\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}}$$

and

$$a = \frac{1}{n} (\Sigma X - b\Sigma Y)$$

where n = the number of aircraft in the sample. Derivations of relationships from which these equations were derived are presented in Engineering Statistics (Reference B-1).

Using these equations the values for the line in Exhibit III-8 are:

$$a = 120.211$$

$$b = 29.011$$

Considering the index (density) as a multiple statement (W ÷ V), this equation could be considered as a multiple linear regression line. However, when the characteristics are used as two separate independent variables, the multiple non-linear equation in Section III-6-a is obtained.

Discussions and examples of the use of and problems encountered in use of statistical analysis for deriving and evaluating CERs are presented in Reference B-2 through B-5.

Appendix C

EXTRACT FROM INTERIM REPORT

Appendix C

EXTRACT FROM INTERIM REPORT

This appendix presents a documenting of the results of a cost estimator's initial evaluation in a cost estimating task. It includes his opinion on:

- The availability of CERs.
- The data available.
- The implications of this lack of data.

This evaluation was extracted from an interim report prepared for the Comptroller of the Army.

Extract from Chapter 3
"Cost Analysis of the Main Battle Tank, MBT-70 (U)"
Prepared for the Comptroller of the Army by
Resource Management Corporation, Incorporated

METHODOLOGY

The basic methodology proposed for this study was the application of multiple regression analysis to historical cost and technical data on tanks and related tracked vehicles and vehicle components, with engineering and analog analysis to supplement and complement the statistical analysis. Because of problems in the data base, however, the latter approach has been used extensively. Regression analysis has not proved useful.

The chapter is divided into two major sections: the first discusses the data base, and the second discusses the general method of analysis and the work breakdown structure used in analyzing the tank cost.

DEVELOPMENT OF A DATA BASE

For the most part, no readily available data base existed at the inception of the research effort. It was necessary, therefore, to develop one. However, several problems in the collection of data and the nature of the data collected are significant, since they impose limitations on the extent to which statistical analysis can usefully be performed and on the kinds of conclusions that can be drawn. The most significant of these problems are discussed in the paragraphs below.

There is no large body of tank data available because, strictly speaking, very few tanks have been developed. The inventory of heavy tanks includes only the M48 and M60 series; the M60 tanks are evolutionary versions of the much older M48, so actually only one heavy tank, in many versions, is available for analysis. However, this series of tanks can be considered as only one point in the statistical sample. Data on the Sheridan M551 light tank, which is much smaller than the MBT-70 and is made of aluminum, are available, as are some data on the M41 and the M47 tanks. Unfortunately the M47 data lack sufficient detail to be of real value. These data--all that are available to the analysis--are hardly enough for a statistical analysis. Several tracked vehicles (the M109, M113, and M114) have been developed and, although these are not tanks, they do permit some enlarge-

ment of the data base. Nevertheless, available data are insufficient to permit multiple regression analysis of whole vehicles.[1]

Cost and technical data on major vehicle components are limited and some of them are not too useful as a base for extrapolation to the MBT-70. The data on tank component costs are limited primarily because the vehicles have been bought on fixed-price contracts, which have no requirement for the contractors to provide the Army with detailed manufacturing costs by component. Some of the historical data are not relevant as a base from which to predict MBT-70 component costs; for example, all predecessor tanks have been equipped with torsion bar suspension systems, whereas the MBT-70 is to have a new suspension system based on a different concept. Detailed cost or technical information on the older systems is therefore of little real value.

Some cost data available to the analysis are of dubious quality. The quality of some data for cost analysis purposes has been degraded by the inclusion of irrelevant costs. An instance of this is the impact on cost of mobilization base requirements: At the beginning of the Korean conflict, the Army paid for the establishment of several production facilities to meet war needs for tanks and vehicles.

Unfortunately, some of the initial mobilization costs are reflected in the unit costs of vehicles produced during the war years. Some postwar unit costs may also be distorted by costs relating to sustaining the mobilization base. Another impact on costs attributable to the Korean War occurs because the emphasis during the war was on producing as many tanks as possible, whereas after the war, there was an increase in competition for tank contracts. Such changes in the market situation would normally result in lower costs (to the customer), and this factor is apparent in the data collected for this study.

Another obstruction to full use of the cost data concerns the identification of research and development costs and other nonrecurring costs. The nature of the fixed-price contracts under which most vehicles have been procured is such that many R&D and other nonrecurring costs are included in unit production prices. Unfortunately, detailed manufacturing cost

1. Regression analysis would have to be performed with costs as the dependent variable and physical or performance characteristics as the independent variables. To explain costs adequately, a quantity of independent variables sufficient to identify mobility, protection, fire-control capability and accuracy, and armament characteristics would be required. The number of such variables would undoubtedly exceed the limited number of vehicles on which data are available.

data are not available, so a reliable identification of the nonrecurring cost is not possible. A factor further aggravating the situation is that much of tank manufacturing is accomplished by subcontractors; the details of true costs are thus further obscured.

A further problem relates to the sensitivity of costs to production rate. It appears that the industry has a relatively large fixed overhead, which is amortized over the quantity of vehicles produced. Variations in the quantity may result in a considerable variation in component and aggregate unit costs.

Data Sources

Data were collected from several sources to permit the required analysis. A list of references included at the end of this report cites specific documents and reports. In summary, data have been collected from the following types of sources:

(1) pricing studies
(2) ATAC pricing and negotiation forms
(3) audit reports
(4) technical specifications
(5) technical information reports
(6) study reports from the Research Analysis Corporation
(7) "Program Manager's Master Plans"
(8) "Army Materiel Plans"
(9) contract summary questionaires and proposals

The nature of the data collected so far can be summarized as follows:

Cost Data

(1) Basic price data, by contract, for contractor-furnished equipment for vehicles procured since 1950 for M60 series, M48 series, M47 series, M41 series, M103, M109, M113, M114, and Sheridan M551. (Some gaps exist in the data for some vehicles).

(2) For some contracts in some years, detailed data on M60 series, M48 series, and M41 series tanks. The detail includes labor, material (including subcontracts), overhead, G&A, and profit for the overall vehicle. In some instances material costs can be matched with major components.

(3) Some component cost data for GFE items, particularly engines, transmission, armament, and selected fire-control items.

(4) Some cost data on analogous devices in non-Army equipment (for example, Navy gun loaders and submarine periscope components).

(5) Some material cost data from primary metal suppliers.

Technical Data

(1) Some physical and performance characteristics on the vehicles mentioned above.

(2) Physical and performance characteristics on many major components of vehicles.

METHOD OF ANALYSIS

Although statistical regression analysis was to have been the major technique employed in the study, it is apparent that data problems preclude this method. Some regression analysis may eventually prove fruitful for engine and transmission costs, but it has not yet been attempted because of time limitations. The development of the cost estimates must therefore rely heavily on an engineering and analog approach. This method is commonly used to estimate costs for items in production as well as for items that are only in a developmental state.

The essence of the engineering and analog approach is rather simple. The cost-significant characteristics of the device being estimated--that is, the characteristics which, when changed, are known from judgment or experience to produce a change in cost--are identified. Devices similar to the one being estimated are then identified as analogs. The major cost-significant characteristics and costs of these analogs are then plotted and trends noted. With a knowledge of trends and the given characteristics of the new device, judgment is then applied to obtain an estimate for the new device.[1] The entire process is, of course, replete with judgment and lacks the analytical sophistication of regression analysis. It follows that it is more difficult to assess adequately the confidence that can be placed in the resultant estimates.

In many instances it was not possible to obtain sufficient quantities of data to permit any kind of analytical treatment of cost trends or even qualitative assessment of the relationship between cost and physical and performance characteristics. This was true particularly in the area of fire-control components. In these cases, when it was necessary to rely heavily on judgment,

1. The amount of judgment required depends on how well trends are defined, whether or not there are conflicting trends when other variables are examined, and what weight one assigns to the impact of a particular variable in relation to other cost-significant variables.

attempts were made to obtain expert judgment from technicians in government laboratories or from contractors to the government.

The application of the engineering and analog technique relies heavily on an adequate technical definition of the device which is to be estimated. The MBT-70 is, in general, adequately defined, with the exception of the hull and turret. At this time neither the hull and turret materials nor the method of fabrication have been selected. For this reason several alternative assumptions were made, and estimates were prepared for several hypothetical tank designs. These assumptions are documented in the next chapter.

Appendix D

BASIC ORGANIZATION THEORY

Appendix D

BASIC ORGANIZATION THEORY

Three main structural types may be taken as representing the forms taken by nearly all organizations. They are: line; line and staff; and functional. The line type of organization is the oldest and simplest form which is also referred to as being "scalar," "hierarchical," or "traditional." Its primary characteristic is the ordering of the organizational elements more in terms of relative authority and responsibility and less in terms of functions performed. Thus, a direct chain of command links the top-most level to the successively lower levels.....

The line type of organization may be effectively used in relatively small organizations. As organizations enlarge, increasing demands are placed on the executives for managerial and technical know-how and for performing more detailed, specialized, and complex administrative tasks. At the point where the executive can no longer be effective without substantial specialized assistance, the line and staff organization form becomes advisable. In this form function receives greater stress. Specialized groups reporting to the executive provide advice and services not only to the executive but on his behalf to the subordinate line elements as well. Thus, subordinate elements in the line have more than direct, primary supervision over them; they now have secondary sources of direction and assistance.....

As has been indicated, staff elements in a line and staff organization perform in different kinds of roles. There is first the advisory and coordinating role in which the staff elements are essentially extensions of the executive himself carrying on for the executive those functions which he would do himself if he had the time. They help plan, develop directives, or coordinate actions of subordinates, all in the name of the executive's authority. Another role of a staff group is the provision of technical expertise. An operations research group might be considered as technical staff for the executive....

Problems arise in the line and staff type of organization from the possible division of sources of authority. Staff groups are sometimes prone to step into the position of directing the lower line elements without following down the full chain of command. Confusion then arises as to whose direction to follow.

The resolution of such conflicts is the subject of much organizational bickering. Some business organizations have been known to be uncertain whether a given function is truly staff or line or even whether this distinction is realistic. The point at issue is whether certain functions traditionally thought to be staff are too crucial to line operations to be so considered any longer. Engineering, purchasing, and finance staff groups, for example, are sometimes spoken of as bearing heavily on line activities and therefore should be in the line. The tendency appears to be in the direction of placing such elements in the line rather than the staff.

The functional organization tries to answer the question: How can any one supervisor direct tasks which are within many different specialized fields? The solution, originally offered by Frederick W. Taylor, is the functional arrangement, whereby a series of supervisors is provided for any one worker, each supervisor responsible for a single leading function. The most clearly suitable circumstance for such an organizational pattern exists when a workman performs different tasks at different times, the work period for each task being unquestionably distinct. He then shifts from supervisor to supervisor for each job....

.... Part or all of the subordinates may at one time work for one of the supervisors and at other times work for the other supervisor. Thus, the varied specialized contributions offered in a secondary fashion by the staff in a line and staff organization are directly furnished through the supervisory line in a functional organization.

The problems of this arrangement are obvious. Unity of command is not clearly enforced, and there may be placed upon the lowest levels of the organization the undesirable burden of deciding who the boss is at any given time. While a completely functional organization cannot be expected to succeed, various mixtures with line and staff organizational principles can in many instances prove to be valuable in management. The flexibility and efficiency which functional supervision allows can be built into a strong line and staff structure with its advantage of unity of command.

Extracted from:

Industrial College of the Armed Forces, National Security Management - Management: Concepts and Practice. Edited by Fred F. Brown, 1967. Part I, Chapter II, "Organization and Management," pages 24-27.

Appendix E

GLOSSARY

Appendix E

GLOSSARY

The definitions presented in this Glossary have been accumulated from diverse sources. Each definition is referenced to its source using the following notations:

AD - Headquarters, Department of the Army. Dictionary of United States Army Terms. Army Regulation 320-5 April 1965

AMC/H- This Handbook

AMC/R- U.S. Army Materiel Command. Resource Management-Cost Analysis Principles and Responsibilities, AMC Regulation 11-31, Volume I. 29 March 1967

ASPR- Department of Defense. Armed Services Procurement Regulations.

DOD/I- Department of Defense. Glossary of Terms Used in the Areas of Financial, Supply and Installation Management, DOD Instruction 5000.8. June 15, 1961.

WEBSTER- G. & C. Merriam Co. Webster's Seventh Collegiate Dictionary 1967

CONDITIONED ESTIMATE - An adjustment of the technical estimate to allow for product improvement, technical difficulties, technical estimating accuracy, etc. (AMC/H)

COST ANALYSIS - 1. The process of review and evaluation of cost data and the reduction of complex cost data into simpler and more basic expressions which may be used for purposes of comparison, validation, or estimation. (AMC/H) 2. Cost analysis is the review and evaluation of a contractor's cost or pricing data to the estimated costs, in order to form an opinion on the degree to which the contractor's proposed costs represent what performance of the contract should cost, assuming reasonable economy and efficiency. (ASPR)

COST ESTIMATE - A statement of the approximate cost to be incurred in the conduct of an activity such as a project, contract, period of time, etc. (AMC/H)

COST, ESTIMATED - 1. A calculated amount, as distinquished from an actual outlay, based upon related cost experience, prevailing wages and prices, or anticipated future conditions, usually for the purposes of contract negotiation, budgetary or cost control, or reimbursement. May relate to a materiel item, project, job, contract, or function, or part thereof. 2. The amount stated in a cost-type contract as the estimated cost thereof. (DoD/I)

COST ESTIMATING - The process of producing a statement of the approximate cost to be incurred in the conduct of an activity such as a project contract, period of time, etc. (AMC/H)

COST ESTIMATING RELATIONSHIP - A cost estimating relationship estimated on the basis of a certain variable or set of variables. The relationship is derived by analyzing historical data on different systems to obtain a functional relationship between several system characteristics. The variable to be estimated will be called the dependent variable and the variables to which the dependent variable is related by the CER will be called the independent variables. A CER in which the cost is directly proportional to a single independent variable is called a cost factor. (AMC/R)

COST TRACKING - Generally, a process which collects and evaluates data in determining the reasons for variances between successive cost estimates or between planned versus actual costs. (AMC/R)

COST INFORMATION - Any intelligence which reflects or affects (1) the magnitude of an expenditure of resources or (2) the credibility of a source document containing such intelligence. (AMC/H)

DEFINITIVE SPECIAL STUDY - An analysis which utilizes firm-priced bids, engineering drawings, spare parts lists and estimates on all supporting services and equipment. These are the detailed estimates upon which the final comparison and decisions can be made and at which comparability and compatibility between cost estimates and actual performance can be established with a high level of confidence. (AMC/H)

DISBURSEMENTS, CASH - 1. With respect to fund reporting, the amount of "expenditure" checks issued and cash payments made, net of refunds received. Excludes "non-expenditure" checks, but includes all advances. 2. All payments. (D

GROSS PARAMETRIC SPECIAL STUDY - An analysis which utilizes gross parametric cost engineering inputs based on preliminary engineering calculations, sketches, and diagrams. Typically, these will consider broad concepts of power, output, subsystem weights, volumes and associated performance constraints. Gross parametric analysis is useful, generally, only for order of magnitude estimates and initial cost analyses, particularly those made for the purpose of feasibility and long range force studies. (AMC/H)

INTELLIGENCE - The product resulting from the collection, evaluation, analysis, integration and interpretation of all available information which is immediately or potentially significant. (AD)

LEARNING CURVE - A graphic or mathematical technique (usually log-linear) which describes the rate of change in recourse expenditure (on a unit or cumulative average basis) as a function of number of units. (AMC/H)

METHODOLOGY - 1. A body of methods, rules, and postulates employed by a discipline. 2. A particular procedure or set of procedures. 3. Analysis of principles of inquiry in a particular field. (Webster)

NON-RECURRING COSTS - Costs incurred for efforts of a one-time nature required to establish the configuration (s) or the facilities and capabilities required to produce the operationally useful items. (AMC/H)

ON EQUIPMENT MATERIEL - Items of supply which, although not part of the equipment proper, are issued with and accompany equipment. They are required for equipment first echelon maintenance, operation, armament, fire protection, communications, etc., and to complete the major end item for issue to users. Examples: gun mounts, guns, radios, flashlights, fire extinquishers, sighting and fire control equipment, specified equipment (spare) parts, and tools for maintenance of the equipment. (AD)

PRICE ANALYSIS - Price analysis is the process of examining and evaluating a prospective price without evaluation of the separate cost elements and proposed profit of the individual prospective supplier whose price is being evaluated. (ASPR)

PROCEDURE - 1. The means or methods by which action shall be taken consistent with applicable "principles". 2. A means of implementing "policy" (DoD/I)

RECLAMA - A request to duly constituted authority to reconsider its decision or its proposed action. (AD)

RECURRING COSTS - Costs associated with the repetitive functions performed to produce an operationlly useful item. (AMC/H)

SEMI-DEFINITIVE SPECIAL STUDY - The precision of analysis that utilizes preliminary estimates, engineering data and cost data on Government Furnished Equipment of configuration elements within the system or item being costed. Examples of such configuration elements would be electric power generation plant, lighting system, heating system and preliminary spare part requirements. Semi-definitive analysis leads to a reasonably accurate estimate, but lacks the precision to give estimates upon which contracts can be written. (AMC/H)

SYSTEM - An integrated relationship of components aligned to establish proper functional continuity towards the successful performance of a defined task or tasks. (AD)

TECHNICAL ESTIMATE - Estimate of a precisely described task. This estimate includes provisions for economic escalation, where applicable, and is normally used for contractual purposes. (AMC/H)

Appendix F

ABBREVIATIONS

Appendix F

ABBREVIATIONS

AMC - Army Materiel Command
AMCR - Army Materiel Command Regulation
AMSAC - Army Materiel System Analysis Center
ASPR - Armed Services Procurement Regulation
ATAC - U.S. Army Tank-Automotive Command
AVCOM - U.S. Army Aviation Materiel Command
BY - Budget Year
CAME - Cost Analysis Monthly Exchange
C/DP - Comptroller/Director of Programs
CER - Cost Estimating Relationship
CGAMC - Commanding General, Army Materiel Command
CIR - Cost Information Report
CM^2P - Commodity Management Master Plan
CPFF - Cost Plus Fixed Fee
CY - Current Year
DA - Department of the Army
DCAA - Defense Contract Audit Agency
DCAS - Defense Contract Administration Service
DoD - Department of Defense
ECOM - U.S. Army Electronics Command
FFP - Firm Fixed Price
FPI - Fixed Price Incentive
FY - Fiscal Year
FYDP - Five Year Defense Program
HEAT - High Explosive Anti-Tank
HQ,AMC - Headquarters, Army Materiel Command
IFB - Invitation For Bid
IPR - In-Process Review
IRS - Internal Revenue Service
JSOP - Joint Strategic Objectives Plan
MBT-70 - Main Battle Tank-70
MECOM - U.S. Army Mobility Equipment Command
MICOM - U.S. Army Missile Command
MIRR - Material Inspection & Receiving Report
MPA - Military Personnel, Army
MUCOM - U.S. Army Munitions Command
OCSA - Office of the Chief of Staff, Army
OMA - Operation & Maintenance, Army
OSA - Office of the Secretary of the Army
OSD - Office of the Secretary of Defense
PCR - Program Change Request
PEMA - Procurement of Equipment and Missiles, Army
PEMARS - Procurement of Equipment and Missiles, Army Management Accounting & Reporting System
PERT - Program Evaluation & Review Technique
PM^2P - Project Management Master Plan

POL	-	Petroleum, Oils, & Lubricants
PY	-	Prior Year
QMDO	-	Qualitative Materiel Development Objective
QMR	-	Qualitative Materiel Requirement
RCS	-	Resource Category Structure
RDT&E	-	Research, Development, Test & Evaluation
RFP	-	Request for Proposal
SA/CE	-	Systems Analysis/Cost Effectiveness
TAMPER	-	Tables for Approximation of Mid-Points for Exponential Regression
TECOM	-	U. S. Army Test & Evaluation Command
TOA	-	Total Obligational Authority
WBS	-	Work Breakdown Structure
WECOM	-	U. S. Army Weapons Command

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★ U.S. GOVERNMENT PRINTING OFFICE 1968 345-005 (39)